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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVII.—No. 2769.] *LONDON: FRIDAY, JANUARY 24, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE 9d. BY INLAND POST ... 11d.

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See Advertisement page 20. 6462

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See Advertisement page 53, Jan. 17. 6403

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See Full Page Advt. page 32, Jan. 10.

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6196
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NOTICE.

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COAL MINES DEPARTMENT,

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THE

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The Special Matriculation Examination, or the Entrance Examination, must be passed, with the exception of those who have been engaged in practical work, to secure admission to Courses of Instruction in the Faculty.

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University of Birmingham.

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Professor F. C. LEA, D.Sc., M.Inst.C.E.

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With reference to the

Advertisement which appeared on the 17th inst., it is now notified for information that the date for the RECEIPT of PLANS and SPECIFICATIONS has been EXTENDED from the 24th inst. as there indicated, to JANUARY 30TH. S 167

APPOINTMENTS OPEN.

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Engineering Department.

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TEACHING Graphics and Machine Drawing. For particulars apply to the SECRETARY. R 983

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Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three testimonials, should reach the Principal (from whom further particulars may be obtained) by the 17th March, 1919.

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JOHN J. JACKSON, B.A.,
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Executive Works Manager

REQUIRED, to be responsible for volume and efficiency of output in East Midland Engineering Works employing over 2000 men, and comprising Engine Shops, Boiler and Smith Shops, Steel and Iron Foundries, and Woodworking Departments. He will be required to direct Departmental Managers, and to work in conjunction with a modern system of organised output programme with progress section and cost accounting. Responsible and successful experience in Works Management essential. Replies will be treated confidentially, and must give full particulars including age and salary required.—Address, S 163, Offices of ENGINEERING.

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STRAITS SETTLEMENTS.
GAS ENGINEER'S DEPARTMENT.
(ASSISTANT GAS ENGINEER.)

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Assistant Gas Engineer about

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Works Management.—

WANTED, for large Engineering Works in Manchester District, with wide variety of Manufactures, a first-class ENGINEER as Assistant Works Manager, must be thoroughly trained, experienced in Machine making rather than in Engine building, well up in organisation and progress control, and in modern tooling practice. Good opening for first-rate man. State age, experience, salary required, and send copies of testimonials.—Address, R 731, Offices of ENGINEERING.

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REQUIRED for INDIA, age about 30, single, practical knowledge of AERIAL ROPEWAYS is desirable. Public School education preferred. Position entails negotiations with Government Officials. State full details of experience and references.—Address, S 144, Offices of ENGINEERING.

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THE MUNICIPALITY OF SINGAPORE,
STRAITS SETTLEMENTS.
MUNICIPAL ENGINEER'S DEPARTMENT.
(ASSISTANT ENGINEER.)

The Municipal Commissioners of the Town of Singapore require an

Assistant Engineer, between

25 and 32 years of age, of sound constitution, and unmarried. He must have had a good technical education, with a regular training as a Civil Engineer, and must have a practical knowledge of Surveying, Levelling, and Estimating, and experience in ordinary Municipal Work, especially Sewerage and Sewage Disposal, both in the design and in the construction of new works and in ordinary maintenance. Preference will be given, other things being equal, to applicants who have passed the Examination of the Institution of Civil Engineers (Associate Member), or that of the Institution of Municipal and County Engineers. The engagement will be for three years, and the applicant is to state the earliest date upon which he could be free to leave for Singapore. The selected candidate must pass a medical examination as to his fitness for service in a tropical climate. A second-class passage will be provided by mail steamer, or a first-class passage by other steamer, with half-pay during the voyage out. The salary will be 3600 dollars for the first, 3870 dollars for the second, and 4140 dollars for the third year, with a duty allowance of 720 dollars per annum, all paid monthly, the value of the dollar being two shillings and fourpence sterling. Such local transport allowance as may from time to time be sanctioned by the Commissioners will be paid. Applications, marked on cover "Assistant Engineer," stating age and place of birth, and giving details of education, training, and experience generally, and in Sewerage and Sewage Disposal, referring to the above requirements seriatim, and stating when free, accompanied by copies (only) of testimonials, and also personal references, to be lodged with Messrs. C. C. LINDSAY & PRIRCE, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents to the Municipal Commissioners (from whom further information may be obtained), not later than Wednesday, 5th February, 1919. S 118

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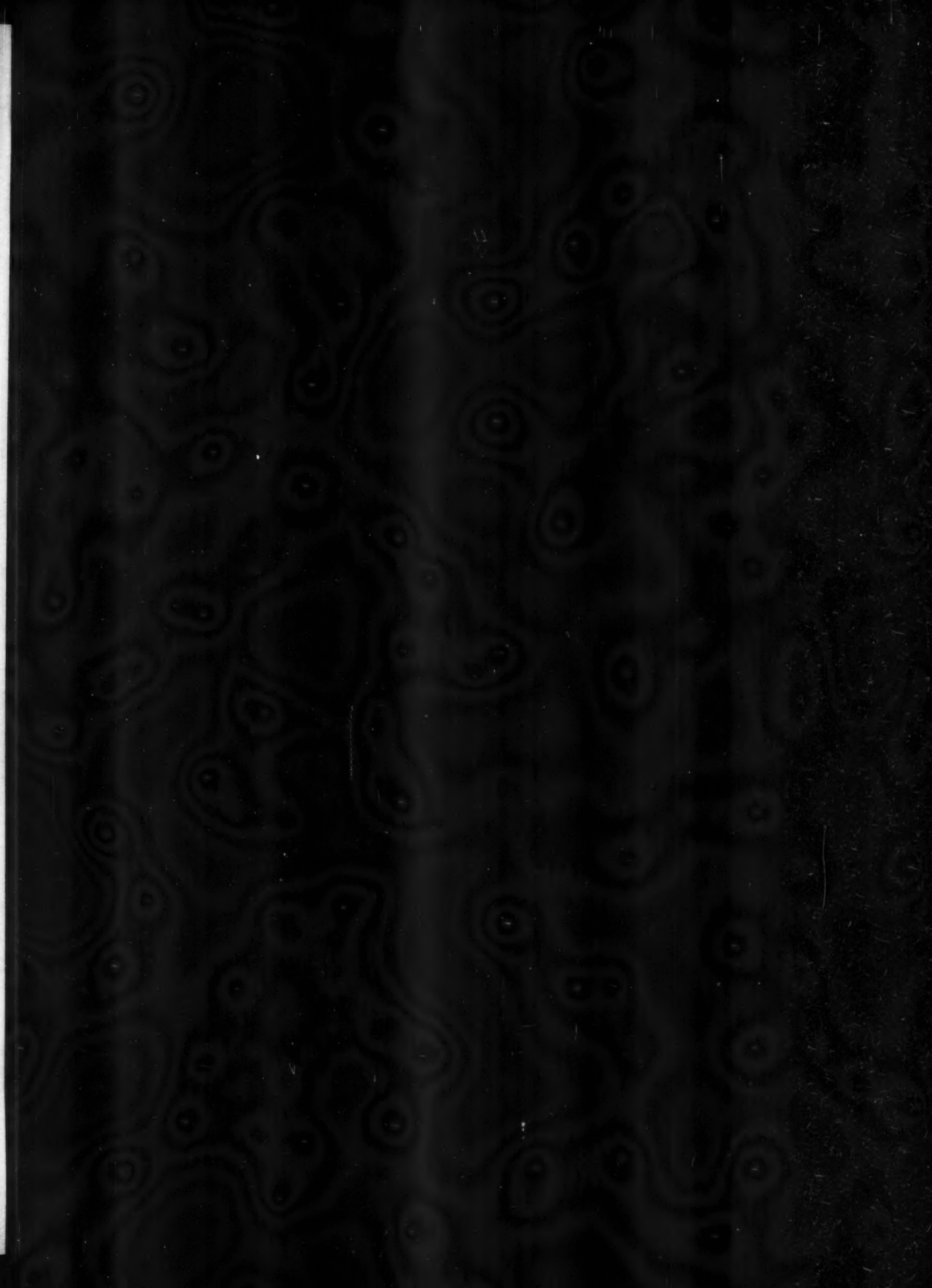


CRITICAL DISTRIBUTED LOADS FOR LONG STRUTS.

By ARTHUR MORLEY and F. F. P. BISACRE.

Introductory.—In former articles in ENGINEERING* one of the present writers has indicated a method of obtaining by successive approximation, the critical load for struts in which the axial load is distributed along the length of the strut.

An important practical case in which such variably-loaded struts occur is the compression flange or member of cantilevers or masts. The present article deals mainly with this case, and it is proposed: (1) To give a general formula applicable to a wide variety of distributed loads and also the rigorous solutions of the problem in certain cases for comparison. (2) To put in a form immediately accessible and useful to the designer or draughtsman, the simple information relating to the ideal collapsing load for struts with types of loading which include nearly all likely to occur in practice. (3) To put before the designer information as to the effects of a varying moment of inertia of cross-section in certain cases.

A typical example of the type of loading contemplated is to be found in the mast or cantilever

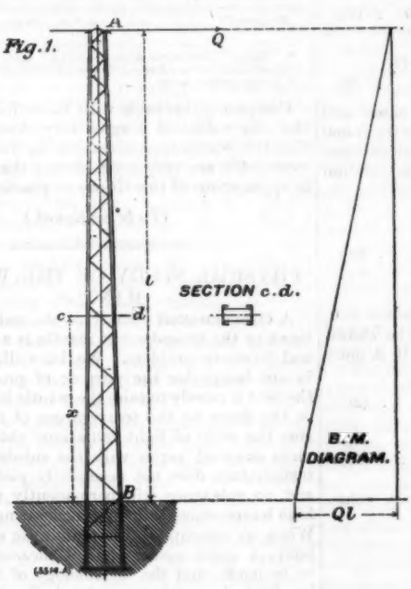


Fig. 1.

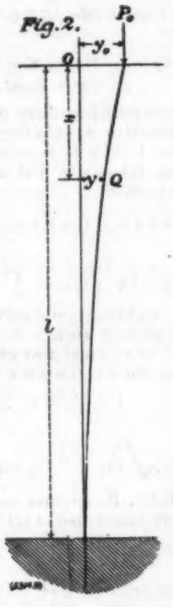


Fig. 2.

A B, Fig. 1, consisting of two uniform channels with the troughs inwards, lightly braced together and subject to a force Q at the end as shown. The channel on the right in the figure will clearly be in compression, the thrust on the channel at any section distant x from the fixed end being greater the nearer the section is to the fixed end.

In the direction perpendicular to the plane of the mast and the line of action of the force Q, the bracing offers little or no support, and the compression member is therefore free to buckle in that direction under the thrust, which varies in amount from zero at the free end to a maximum at the foot of the mast. If the mast has a uniform moment of inertia of cross-section, the thrust at x is proportional to the bending moment at x, and the bending moment diagram for the mast is, of course, easily obtained. In any case, the compressive force diagram for the compression member can be drawn for any loading from the known dimensions of the mast and the conditions of loading.

The problem therefore arises, to determine the critical load for a strut, the thrust on which varies in a known manner, from a given value at the top to a maximum at the foot of the mast.

Notation.—Let P_0 (Fig. 2) be the vertical load at one end of the strut. Let the point O vertically above the other end, and distant l from it, be chosen as origin, from which x is measured vertically downwards, and let P be the thrust at any point Q distance x from O. Then the total load at Q is:

$$P = P_0 + \int_0^x w\,dx$$

where w or dP/dx is the load added per unit length, and the total added load

$$W = \int_0^l w\,dx$$

where l equals the total length of the strut.

Let the ratio $P_0/W = \gamma$. The total load at the end of the strut remote from the origin is:

$$P_1 = P_0 + W = (\gamma + 1)\,W = \lambda\,E\,I/l^2 \qquad (1)$$

where λ is a constant to be determined, I is the generally constant moment of inertia of the area of cross-section of the strut, and E is Young's modulus of elasticity for the material. When $\gamma = 0$, *i.e.*, when $P_0 = 0$, let:

$$W = \lambda_0\,E\,I/l^2$$

where λ_0 is a special value of λ. And when $\gamma = \infty$, *i.e.* when $W = 0$,

$$P_0 = \lambda_\infty\,E\,I/l^2*$$

The rate of addition of load w will not necessarily be constant, but may be either exactly or approximately represented in any given case by a simple algebraic function such that:

$$P = P_0 + W\{a_1\,x/l + a_2\,(x/l)^2 + a_3\,(x/l)^3 + \ldots + a_n\,(x/l)^n + \ldots\} \qquad (2)$$

where the indices 1, 2, 3, 4, . . ., &c., may include integral or fractional values; they will, however, always be positive, and a's are numerical coefficients such that

$$a_1 + a_2 + a_3 + \ldots = 1$$

Let y be the deviation of the strut axis from its original position at a distance x from the origin and measured perpendicular to the axis of x, and let y_0 be the value of y at O. Let R be the reaction, if any, at O in the plane of buckling, estimated perpendicular to the axis of x in the direction in which y is positive. Let M_0 be the bending moment (if any) in the plane of buckling due to any constraint at O.

Determination of Critical Load.—At any point distant x from the origin, the shearing force perpendicular to the axis of the strut in the plane of buckling is:

$$-P\,dy/dx + R$$

hence according to the simple theory of bending:

$$d/dx\,(E\,I\,.\,d^2y/dx^2) = -P\,dy/dx + R = -dy/dx\,\{P_0 + \int_0^x w\,.\,dx\} + R \qquad (3)$$

and integrating this:

$$E\,I\,d^2y/dx^2 + P_0(y - y_0) + y\int_0^x w\,dx - \int_0^x w\,y\,.\,dx = R\,x + M_0 \qquad (4)$$

If $w = 0$, this equation reduces to that for which Euler's value of the critical load is well known.

In the case of the simplest strut (Fig. 2) fixed at one end and entirely free at the other (the origin) $R = 0$ and $M_0 = 0$.

The Method of Successive Approximation.—Briefly this method, as exemplified in the previously-quoted articles, depends on assuming a reasonable form of y as a function of x for the deflection curve and substituting this value in equation (4). The equation is then integrated with due regard to the end conditions, thus giving a new equation for the value of y in terms of P and W, and by substituting the values of x and y corresponding to, say, $x = l$, a value of P or W (and therefore of P + W) is obtained, if γ is fixed. The new and, in general, more correct value of y as a function of x may be treated in the same way as the originally assumed values, and repetitions of the process yield successive values of P_0 or W which approach the true limiting value. With a proper initial assumption as to the form of y, not more than one or two approximations for P_0 or W are necessary, and the correctness of the approximation may be judged by the smallness of the change in successive values of P_0 and W or of y.

The appropriate form of y is one which satisfies the end conditions, and a very satisfactory form is found by assuming that:

$$y = A_0 + A_1\,x/l + A_2\,(x/l)^2 + \ldots + A_n\,(x/l)^n + \ldots \qquad (5)$$

and determining as many as possible of the constants A_0, A_1, A_2, &c., to satisfy the end conditions in regard to y, dy/dx, d^2y/dx^2 and d^3y/dx^3, and making all higher ones zero, *e.g.*, in the case of the strut illustrated in Figs. 1 and 2 free at the origin and fixed in direction at the other end, the value becomes:

$$y = y_0\{1 - \tfrac{3}{4}\,x/l + \tfrac{1}{4}\,(x/l)^4\} \qquad (6)$$

if $P_0 = 0$; otherwise, it becomes:

$$y = y_0\{1 - \tfrac{4}{3}\,(x/l) + \tfrac{1}{3}\,(x/l)^3\} \qquad (7)$$

Simplification for Mixed Loadings.—If the load P takes the form:

$$P = P_0 + W\{a_1\,x/l + a_2\,(x/l)^2 + \ldots\,a_n\,(x/l)^n\}$$

as in (2), equation (4), since R and M_0 are zero, becomes:

$$E\,I\frac{d^2y}{dx^2} + P_0(y - y_0) + W\int_0^x \frac{dy}{dx}\left(a_1\frac{x}{l} + a_2\left(\frac{x}{l}\right)^2 + \ldots\right)dx = 0$$

i.e.,

$$E\,I\frac{d^2y}{dx^2} + P_0(y - y_0) + Wy\left\{a_1\frac{x}{l} + a_2\left(\frac{x}{l}\right)^2 + \ldots\right\} - W\int_0^x \frac{d}{dx}\left\{a_1\frac{x}{l} + a_2\left(\frac{x}{l}\right)^2 + \ldots\right\}y\,dx = 0$$

i.e.

$$E\,I\frac{d^2y}{dx^2} + P_0(y - y_0) + Wy\left\{a_1\frac{x}{l} + a_2\left(\frac{x}{l}\right)^2 + \ldots\right\} - \frac{W}{l}\int_0^x \left\{a_1 + 2a_2\frac{x}{l} + 3a_3\left(\frac{x}{l}\right)^2 + \ldots\,a_n\left(\frac{x}{l}\right)^{n-1}\right\}y\,dx = 0 \qquad (8)$$

Putting the first approximation to the deflection curve as in (7):

$$y = y_0\left\{1 - \tfrac{4}{3}\frac{x}{l} + \tfrac{1}{3}\left(\frac{x}{l}\right)^3\right\} \qquad (9)$$

the first integration can be performed and the integration constant C can be split up so that:

$$C = C_0 + C_1 + C_2 + \ldots$$

where C_0, C_1, C_2 . . . are the values C would have if all the terms except the one under consideration were absent.

Performing the second integration and splitting up the integration contant D, say, in the same way, the following equations are obtained:

$$y.EI/l^2 = P_0 y_0 f_0(x) + W a_1 y_0 f_1(x) + W a_2 y_0 f_2(x) + \ldots$$

and

* "Critical Loads for Ideal Long Columns," April 24, 1914, p. 566. "Critical Loads for Long Tapering Struts," September 21, 1917, p. 295. "Long Columns carrying Distributed Loads," November 30, 1917, p. 565.

* The symbol λ has been used in place of J of the previously quoted article on "Long Columns carrying Distributed Loads" to avoid confusion with the use of J in the present article to denote a Bessel function in accordance with a practice which is universal.

$y_0 . E I/l^2 = P_0 y_0 f_0(o) + W a_1 y_0 f_0(o) + W a_2 y_0 f_0(o) + \ldots$,

or

$$E I/l^2 = P_0 f_0(o) + W\{a_1 f_1(o) + a_2 f_2(o) + \ldots a_n f_n(o)\} \quad (10)$$

Now since equation (9) would be taken to obtain a first approximation to the critical load for any single term in (2) if all the others were absent, and since in integrating (8) each term has been integrated with its own constants separately, it follows that $f_0(0)$, $f_1(0)$, &c., are the reciprocals of the first approximations to the critical load coefficients which would be obtained for each term, if all the others were absent, or :

$f_0(o)$ is the first approximation to $\frac{1}{\lambda_\infty}$

$f_1(o)$ is the first approximation to $\frac{1}{{}_1\lambda_0}$

$f_2(o)$ is the first approximation to $\frac{1}{{}_2\lambda_0}$

and so on, or

$$E I/l^2 = \frac{P_0}{\lambda'_\infty} + \frac{W a_1}{{}_1\lambda'_0} + \frac{W a_2}{{}_2\lambda'_0} + \ldots \frac{W a_n}{{}_n\lambda'_0} \ldots \quad (11)$$

Putting $P_1 = (1+\gamma)W$, *i.e.*, $P_0 = \gamma W$ as before :

$$\frac{E I}{l^2} = \frac{P_1}{1+\gamma}\left\{\frac{\gamma}{\lambda'_\infty} + \frac{a_1}{{}_1\lambda'_0} + \frac{a_2}{{}_2\lambda'_0} + \ldots \frac{a_n}{{}_n\lambda'_0}\right\}$$

And since $\lambda E I/l^2 = P_1$ by equation (1) :

$$\lambda' = \frac{1+\gamma}{\frac{\gamma}{\lambda'_\infty} + \frac{a_1}{{}_1\lambda'_0} + \frac{a_2}{{}_2\lambda'_0} + \ldots \frac{a_n}{{}_n\lambda'_0}} \quad (12)$$

or

$$\lambda' = \frac{1+\gamma}{\frac{\gamma}{\lambda'_\infty} + \Sigma\left(\frac{a_n}{{}_n\lambda'_0}\right)} \quad (13)$$

where λ' is the first approximation to the critical load coefficient for the mixed load and λ'_∞, ${}_1\lambda'_0$, ${}_2\lambda'_0$, &c., are the first approximations to the critical load coefficients for each term separately, if all the others were absent, these first approximate values being calculated from the same assumed form of deflection in each case.*

It will be shown later, by calculating some special cases that, provided $d P/d x$ is continuous and positive (12) is a close approximation to the true value if either the accurate or first approximate values of λ_∞, ${}_1\lambda_0$, ${}_2\lambda_0$, are used in it. The general case of loading (2) may therefore, for an approximate solution, be made to depend upon the simple case :

$$P = a_m (x/l)^m W \quad (14)$$

First and Second Approximations in Case.—($P = W a_m (x/l)^m$.

For the fixed free strut of Fig. 1, giving y the initial value (6), the first approximation to ${}_m\lambda_0$ is :

$${}_m\lambda'_0 = \frac{4}{3}\left\{\frac{1}{(m+1)(m+3)} - \frac{1}{(m+4)(m+6)}\right\} \quad (14a)$$

and the second is :

$${}_m\lambda_0'' = \frac{1}{(m+1)(m+2)}\left\{\frac{1}{(m+1)(m+3)} - \frac{1}{(2m+3)(2m+5)}\right\} - \frac{1}{(m+4)(m+5)}\left\{\frac{1}{(m+1)(m+3)} - \frac{1}{(2m+6)(2m+8)}\right\} \Big/ \frac{1}{(m+1)(m+3)} - \frac{1}{(m+4)(m+6)} \quad (14b)$$

Substituting numerical values for m the following values are obtained :—

TABLE I.*

m	0	1/3	½	1	1.5	2	3	4
${}_m\lambda_0'$	2.57	3.98	4.80	7.78	11.601	16.36	29.08	46.67
${}_m\lambda_0''$	2.467	3.94	4.79	7.826	11.598	16.116	27.42	44.22

* In obtaining the values given in Table I for λ's, the form (6) has been used as the first approximate deflection curve, which implies that $P_0 = 0$. If P_0 were not zero, the form (7) should strictly be used, though this is not the form suggested as most suitable if each term $W a_m (x/l)^m$ is considered separately, in which case $P_0 = 0$; but the second approximations by either initial form (6) or (7) differ but little and are both very close to the true values, as will be seen by comparing Tables I and II.

Subsequent values differ but little from the first results, and the closeness of these coefficients to the true values may be confirmed by the rigorous solution of this case which is possible for all positive values of m.

* In certain cases where the differential equation (4) can easily be solved, *e.g.*, when I is everywhere proportional to the bending moment M, and R = O, equation (13) is strictly true and not merely for the first approximations to the coefficients.

Rigorous Solution. I. *Constant.*—Any case where the load P is such that the equation

$$E I\, d^5 y/d x^5 + P\, d y = 0 \quad (\text{see } (3)) \quad (15)$$

can be put in the form

$$d^2 i/d x^2 + K i x^m = 0 \quad (16)$$

where K is a constant, is soluble in terms of Bessel functions. Greenhill and others have made use of his method.*

The solution is :

$$\left.\begin{aligned} i &= x^{\frac{1}{2}}\left[A J_{\frac{1}{m+2}}(\xi) + B J_{-\frac{1}{m+2}}(\xi)\right] \\ \text{or}\quad i &= x^{\frac{1}{2}}\left[A J_{\frac{1}{m+2}}(\xi) + B Y_{\frac{1}{m+2}}(\xi)\right] \\ \text{where}\quad \xi &= \frac{2\sqrt{K}}{m+2}\, x^{\frac{m+2}{2}} \end{aligned}\right\} \quad (17)$$

and J's and Y's are Bessel functions of the first and second kind ; according as $m+2$ is not or is the reciprocal of an integer. The only case of failure is where $m+2=0$; but this case does not arise in this problem.†

Taking the origin at the free end as before and assuming a load

$$P = W a_m (x/l)^m \text{ as in } (14)$$

equation (15) gives :

$$d^2 i/d x^2 + (W a_m/E I)(x/l)^m . i = 0 \quad (18)$$

where

$$i = dy/dx . \quad \text{Putting } K = W a_m/E I l^m,$$

$$d^2 i/d x^2 + K x^m i = 0 \quad (19)$$

Now m is essentially positive in actual cases and may range from 0 to ∞, including of course fractional values. Also $1/(m+2)$ is always fractional and lies in value between ½ and zero ; the solution required is therefore :

$$\left.\begin{aligned} i &= x^{\frac{1}{2}}\left[A J_{\frac{1}{m+2}}(\xi) + B J_{-\frac{1}{m+2}}(\xi)\right] \\ \text{where}\quad \xi &= \frac{2}{m+2}\sqrt{\frac{W a_m}{E I l^m}} \cdot x^{\frac{m+2}{2}} \end{aligned}\right\} \quad (20)$$

The end conditions are $d i/d x = 0$ when $x = 0$, and y and i are zero when $x = l$. It can be shown that, for $d i/d x$ to equal zero when $x = 0$, A must be zero, hence for $i = 0$ when $x = l$:

$$J_{-\frac{1}{m+2}}(\xi) = 0 \quad (21)$$

where

$$\xi = \frac{2}{m+2}\sqrt{\frac{W a_m}{E I l^m}} . l^{\frac{m+2}{2}} = \frac{2}{m+2}\sqrt{\frac{W a_m}{E I}} . l \quad (22)$$

When (21) holds, B can have any arbitrary value. Let ${}_m\xi_0$ be the lowest root of (21), then :

$$W a_m = \left(\frac{m+2}{2}\right)^2 {}_m\xi_0^2 \frac{E I}{l^2}, \text{ by (22)}$$

$$\text{therefore } {}_m\lambda_0 = \left(\frac{m+2}{2}\right)^2 {}_m\xi_0^2 \quad (22a)$$

Now $J_n(\xi) = \frac{\xi^n}{2^n \Gamma(n+1)}\left\{1 - \frac{\xi^2}{2^2(n+1)} + \frac{\xi^4}{2^4 . 2!(n+1)(n+2)} - \frac{\xi^6}{2^6 3!(n+1)(n+2)(n+3)} + \right\}$

$$= \frac{\xi^n}{2^n \Gamma(n+1)} S_n(\xi) \quad (23)$$

hence, if ξ is not zero, in order that $J_n(\xi)$ shall vanish, $S_n(\xi)$ must equal zero.

Hence (21) is equivalent to

$$S_{-\frac{1}{m+2}}(\xi) = 0$$

where $-1/(m+2)$ is put for n in the series given. This is an equation in ξ to determine the admissible values of ξ. The first value of ξ which makes $S_{-\frac{1}{m+2}}$ converge to zero can readily be found by trial—or it can be found by MacMahon's formula :

$$\xi = \left\{a - \frac{s-1}{8a} - \frac{4(s-1)(7s-31)}{3.(8a)^3} - \frac{32(s-1)(83s^2 - 982s + 3779)}{15(8a)^5} - \right] \quad (24)$$

$$\text{where } a = \frac{\pi}{4}\left(3 - \frac{2}{m+2}\right) \text{ and } s = \frac{4}{(m+2)^2}$$

The roots so obtained are approximate, depending on the convergence of the terms in (24). This gives, in any case, the approximate root which can be checked and adjusted if necessary by means of the series

$$S_{-\frac{1}{m+2}}(\xi).$$

The application of these results to special cases is simple, and some cases are summarised in Table II, where

$$W a = \lambda \frac{E I}{l^2}, \text{ and } l' = \sqrt{\frac{\pi^2}{4\lambda}}\, l = \mu l$$

the equivalent length of the simple strut carrying an end load equal to $a_m W$ and ρ = ratio of load at $x = l/2$ to the load at $x = l$. This quantity will be referred to later.

TABLE II.

Loading. P	m in $J_m(\xi) = 0$	${}_m\xi_0$	λ	μ	ρ
$W a_{\frac{1}{2}} (x/l)^{\frac{1}{2}}$	- 4/9	1.67_{78}	3.54	0.835	0.841
$W a_{\frac{1}{3}} (x/l)^{\frac{1}{3}}$	- 3/7	1.70_{91}	3.93	0.792	0.794
$W a_{\frac{2}{5}} (x/l)^{\frac{2}{5}}$	- 2/5	1.75_{39}	4.81	0.716	0.707
$W a_1 (x/l)^1$ *	- 1/3	1.86_{68}	7.84†	0.561	0.500
$W a_2 (x/l)^2$	- 1/4	2.00_{83}	16.10	0.391	0.250
$W a_3 (x/l)^3$	- 1/5	2.08_{83}	27.26	0.301	0.125
$W a_4 (x/l)^4$	- 1/6	2.14_{23}	41.30	0.244	0.0625
$W a_5 (x/l)^5$	- 1/7	2.18_{05}	58.24	0.206	0.0312

* "Height Consistent with Stability," Love's "Math. Theory of Elasticity," where Greenhill's work is briefly summarised.
† Heim gives 7.83725. . . .

Comparing this table with Table I, it will be seen that the values of λ agree very closely, indicating that the second approximations in Table I obtained from (14*b*) are very good—better than are required in applications of this theory to practice.

(To be continued.)

* Cambridge Phil. Soc. Proc., vol. iv., 1818.
† Forsyth's "Differential Equations."

PHYSICAL STUDY OF THE WELSBACH MANTLE.

A COMPREHENSIVE study of the radiation phenomena of the incandescent mantle is a very complex and intricate problem. We burn illuminating gas in our lamps for the purpose of producing light ; the heat is merely to raise the mantle body suspended in the flame to the temperature of incandescence. But the ratio of light radiations obtained to heat units supplied varies with the substance, a higher temperature does not necessarily yield more light, and no substance will permanently withstand the high temperature without deteriorating in some way. When we attempt to determine the efficiency of a lamp, a great many difficult measurements have to be made, and the terminology of the quantities involved is confusing. A simile suggested by R. W. Wood may help to indicate the nature of the problem. Imagine a cylindrical vessel into which water is flowing at a constant rate. The walls of the cylinder are perforated with holes of different sizes ; let the lower holes be large, the upper holes smaller. The water squirting out through the holes represents radiations, of small and large wave length according to the size of the holes ; the height to which the water rises corresponds to the temperature. When there are only a few holes, the water will rise high, the radiations will be of light rather than of heat, but the total radiation will be small. Suppose, further, the cylinder to be leaky because the soldered edges of the metal sheet, from which the cylinder was made, do not close up properly. Then the higher the water rises, the more water will be lost by leakage, and that leakage will represent the heat energy directly lost by conduction and convection in the lamp and by heating the air ; with constant feed this leakage will offset the advantages of the higher temperature. The simile does not cover more than some of the problems which have to be solved in the investigation of the incandescence lamp, and it is not astonishing that few investigators have faced the complete mantle problem. Auer von Welsbach himself did a great deal in his time ; the first physical theory of the mantle was given by H. Rubens in 1905 and 1906 (*Annalen der Physik*), and apart from a few special investigations there was no further comprehensive study of the subject till quite recently when Herbert E. Ives, E. F. Kingsbury and E. Karrer took it up in the Research

Laboratories of the Welsbach Company, of Gloucester City, New Jersey (Journal of the Franklin Institute, October and November, 1918, pages 401 to 438 and 585 to 625). The energy relations have received particular attention in this research, and some hope of increased mantle efficiency has been obtained. As there is much diversity as to terms we shall have to introduce our account of this interesting research by a brief statement of the terms used by the investigators and of the chief laws underlying the study.

Any substance at a temperature above absolute zero emits radiations of different wave lengths λ in form of heat and light. The radiations may be purely thermal and strictly subject to the law of thermodynamics, or there may also be a "luminescence" due to electric or other forces. The total radiant emission R is the sum of all the emissions E_λ. When there are in any enclosed system different processes going on at different temperatures, a mutual exchange of heat will take place between the various bodies until equilibrium is established; the equilibrium is dynamic, not static, however, that is to say, the radiation and consequent loss of heat from any portion do not continue until the temperature has sunk to a certain degree, when absorption would set in, but radiation and absorption proceed simultaneously. Of the radiated energy falling upon a body, part A is absorbed, part R^1 is reflected, part D transmitted, so that $A + R^1 + D = 1$. In the case of metals R^1 is large and D small; the opposite holds for gases. As a rule a body will not absorb all the incident radiation; but according to Kirchhoff's law the ratio E/A is, for a given temperature T and λ, constant for all bodies. When all the radiant energy is absorbed, the body is called a "black body" (Kirchhoff) or a full radiator. Such a body does not exist; the black body of Lummer and Pringsheim, an enclosed space, *e.g.*, an electric furnace, provided with walls impervious to heat and with a small aperture for taking observations, is a fair approximation to it. For the study of the radiation laws these black bodies have proved invaluable. When a body, though not a perfect radiator, does not show selection in absorption or reflection, it is known as a grey body.

On heating a substance the radiations, first of large wave lengths, become more and more of short λ. While the total radiation increases with the fourth power of the temperature ($R = C T^4$, Stefan-Boltzmann), the visible radiation increases near 1,800 deg. C. absolute with the thirteenth power. In other words the energy of maximum radiation shifts more and more to the region of short wave-length (Wien's displacement law: $\lambda/\lambda_1 = T_1/T$). These laws and the formula of Wien-Planck (or some other law) for the energy distribution in the spectrum hold only for black bodies, and with different constants also for grey bodies. Bodies such as mantles with strong selective absorption may deviate considerably from them, and in efficiency determinations we have to refer to black body data. Thus J_λ indicates the radiant emission of a black body at the same temperature as the material tested. The incandescent particles of carbon in a Bunsen flame need not quite assume the full temperature of the flame, which in itself is difficult to determine. The mantle temperature certainly does not come up to the flame temperature, and by black body temperature of a source of light is understood, not the true temperature, but the lower value which a black body should possess to give the same amount of radiation as the body in question. In our incandescence lamps we want merely luminous radiations L_γ which represent, with all our light sources, a very small fraction of the total radiation.

If $R = \int_0^\infty E_\lambda J_\lambda \, d\lambda$, then the luminous emission $L = \int_0^\infty L_\lambda E_\lambda J_\lambda \, d\lambda$. The E is characteristic of the substance used as radiator, J depends upon the absolute temperature according to Wien-Planck's law, and L is fixed by the peculiarities of the human eye, all the quantities being different functions of λ. What we are able to vary is the composition of the radiator and its temperature; to study the effects of these variations a great many elaborate measurements have to be conducted.

In the determination of the total radiant energy R use was made by Ives and his collaborators of a thermopile of 72 bismuth-silver couples, the watts received by the pile per square centimetre of mantle area being measured. Reduced to watts per unit solid angle this quantity gives the specific radiation corresponding to brightness in illumination, and the integral of this value over the whole radiating surface yields the total radiant emission. The emissive power is the ratio of the total emission to that of a black body at the same temperature. For the determination of the radiant luminous efficiency L/R the radiant energy determination has to be repeated after interposing a light filter such as to copy the luminous part of the spectrum as seen by the eye; heat losses do not affect this quantity. The total luminous efficiency, L/P, however, is the ratio of L to the total energy P supplied to the lamp, as deduced from the calorific power and consumption of the gas, and the radiation efficiency is $L/P/L/R = R/P$. The measurement of the spectral distribution of the emission was effected with the aid of a Henning spectropyrometer, on the slit of which the image of the mantle and of a carbon filament lamp, adjusted to the brightness of any colour of the mantle spectrum, were thrown by a mirror; by turning the mirror through 90 deg. it was exactly brought over the mouth of the black-body furnace used for calibrating the apparatus. The similar measurements in the infra-red were made with the aid of a Hilger spectrometer, rock-salt prisms and nickel steel mirrors.

The important determination of the mantle temperature was effected by three methods: (*a*) The optical method (used by Rubens) which is based on the laws of Kirchhoff and of Wien-Planck and presumes that the mantle-edge observed is a practically continuous surface (though only a texture) which does not transmit light and whose reflecting power in the hot condition can partly be deduced. Experimenting with composite mantles, built up of patches of different compositions, and determining the reflecting powers hot and cold, Ives and his colleagues proved that these assumptions were not justified. Observing, however, that black-bulb thermometers, placed near different mantles, might rise highest near the mantle of lowest temperature, the gas consumption being kept constant, they worked out a new radiation method (*c*). But in their actual temperature measurements they relied chiefly on thermocouples (*b*), taking care that as great a length as possible of the wires was lying against the mantle. How this was secured is not described, unfortunately; to be able to eliminate losses by radiation and conduction from the wires, they worked, not with a single couple, but with a series of couples of different wire-diameters, 0·35 mm., 0·25 mm., 0·15 mm., 0·05 mm. respectively. Finally the spectrum of the Bunsen flame was determined, although the flame itself contributes hardly anything to the luminosity. In some experiments the flame was adjusted either for "maximum light" by keeping the flame within the mantle, or for "maximum radiant heat," by letting the flame come through the mantle so as to envelope it. In the case of the pure ceria mantle the difference between the two adjustments was very striking. As the flame was turned up, the mantle gained in brightness until the light dropped off as if quenched, the moment the flame struck through. The pure thoria mantle showed this much less. The mantles, especially prepared for the research by experienced hands, were of the upright, open-cylinder type (not inverted hoods), the fibre being silk or cotton; some flat discs of mantle material were also made for studying the behaviour of the materials under kathode bombardments in a special bulb.

The ideal radiator for a lamp would be one which has all its emission concentrated in the region of maximum light. Such a radiator is unknown. We wish, moreover, fully to utilise the calorific power of the gas to produce light, but not to heat the air and the whole lamp. Hence we search for a substance having high emission in the visible spectrum, and little emission elsewhere. Experience teaches us that this is best attained by using a mixture of two substances, one of which (the base) has a low general emission and is therefore able to attain a high temperature in the flame; the base is to act as carrier for the other substance (the colorant) of high visible emission. Rubens, whose conclusions are confirmed by Ives, called the colorant the sensitiser, because like a sensitiser in photography it gives rise to a special absorption in the visible spectrum. Rubens found that mantles of thoria containing about 1 per cent. of ceria attain in the same flame a higher temperature than when they contain more ceria, because in the latter case there is more emission of heat and consequently more cooling. A simile will make the point clearer. Suppose we sprinkle some black particles on a mantle of low emission; the particles glow brilliantly, and as more particles are added, more light is first produced, but more heat is also lost by radiation from the particles, so that the whole mantle temperature and the glow diminishes. We must effect a compromise. Instead of sprinkling particles on the base, we dissolve the colorant in it. The mesh of the mantle also comes into the question; to ensure good heating, the mesh should be wide, but then the glowing area is small.

In the detailed study on the lines described the guiding principles were therefore the following: When the emissive power of a substance is low, it may supply a good base, but is no use as colorant; when that power is high, the material may be promising alone or as colorant. The first series of measurements were made with mantles of oxides of low emissive power (thoria 4·4 per cent., silica 13 per cent.) which might prove suitable bases for the colorant. In Bunsen flames of 2,050 deg. C. absolute, thoria, magnesia, zirconia, alumina, silica, beryllia attained temperatures of 1,930 deg., 1,840 deg., 1,670 deg., 1,725 deg., 1,650 deg., 1,690 deg.; zirconia appeared to be a fair light producer, but its temperature remained 300 deg. below that of thoria, which clearly proved the best base material; in the further experiments thoria therefore served as base. Nothing better than the Welsbach mixture, thoria with about 1 per cent. of ceria, was found either. The radiant emission of pure ceria is twice that of pure thoria; the emissive power (thoria 4 per cent.) rose for pure ceria to 22 and 40 per cent. for the maximum luminosity and maximum radiation adjustments. With the former adjustment pure thoria reached a temperature of 1,930 deg. C., pure ceria 1,500 deg.; with the latter the temperatures were 1,930 deg. and 1,340 deg. The maximum radiant luminous efficiency was obtained with mantles of 0·75 per cent. ceria; the average value was 0·0043, and it rose to 0·009 in the brightest part of the mantles; 0·0043 is over three times the value for a black body at the same temperature (1,900 deg.). The emission power of the mantle reached its maximum already with very small ceria percentage, the Welsbach mantle being, as Rubens had stated, practically black for the blue end of the spectrum. With higher percentage of ceria the absorption band—the exact position of which is not stated—shifted from the visible spectrum into the infra red, and the temperature fell. Féry ascribed, in 1903, the remarkable efficiency of ceria to its being reduced to metal in the Bunsen flame. Experimenting with reducing and oxidising flames, Ives obtained evidence for the existence of several cerium oxides, differing in colour, but not for any reduction to metal. Pure ceria is white, but turns yellow and brownish when hot. Campbell Swinton had, in 1899, exposed composite mantles to kathode bombardment; pure thoria gave vivid incandescence, pure ceria hardly any light, and the Welsbach mantle yielded no more light than the pure thoria. Repeating and confirming these experiments with the aid of discs, the sectors of which had different compositions, Ives observed that, as the ceria percentage increased, the bombardment produced a more and more dull glow, and the mantles containing ceria were found to have turned bluish-grey; on reheating the mantles in air their original colour returned. This behaviour suggested that the kathode bombardment gives rise to a partial reduction of the ceria which increases its general emission power, but fails to develop the absorption band. This was confirmed by observations of the reflecting power; whilst the reflection in the blue

THE BRITISH ADMIRALTY HYDROGEN GAS PLANT.

CONSTRUCTED BY THE SOCIÉTÉ L'OXYLITHE, PARIS.

(*For Description, see opposite Page.*)

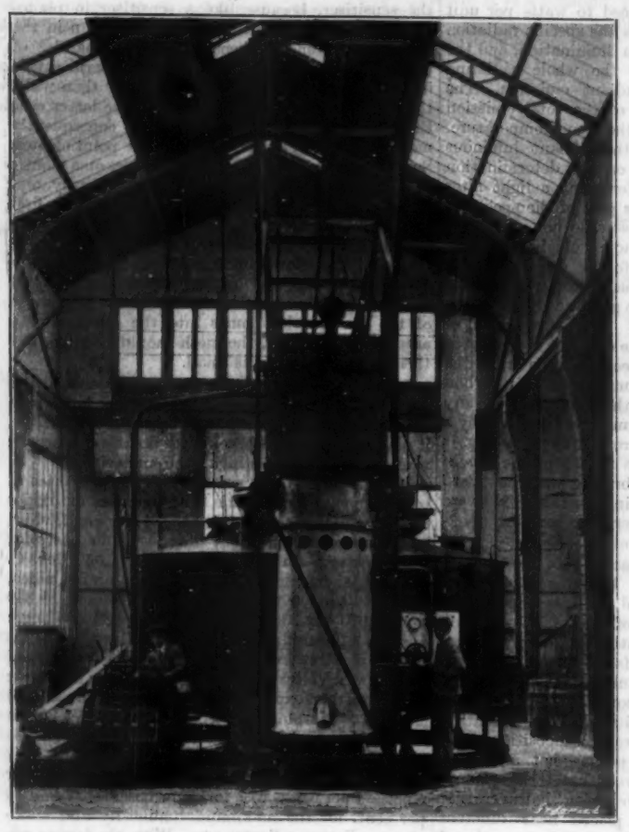


FIG. 1. GENERAL VIEW OF THE BRITISH ADMIRALTY HYDROGEN PLANT.

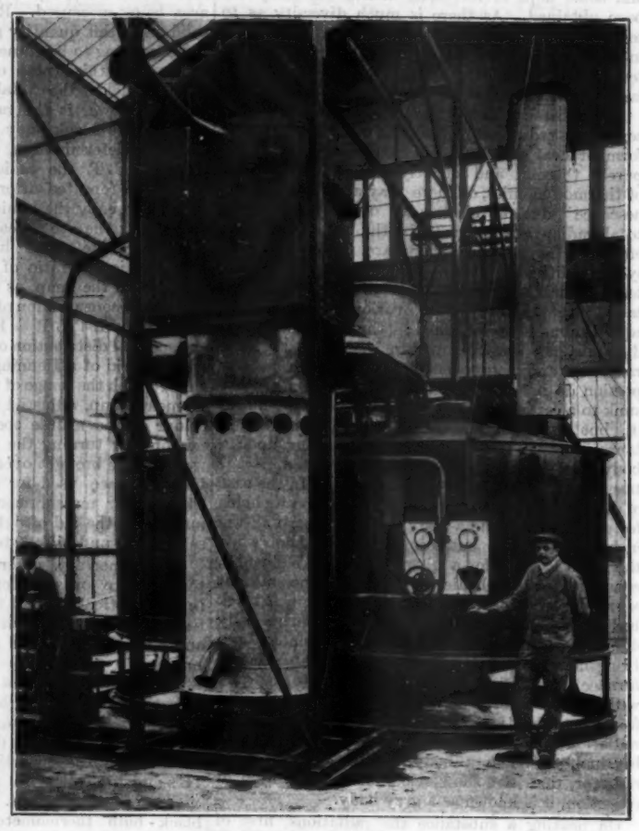


FIG. 3. WATER GAUGE AND VALVE OPERATING GEAR.

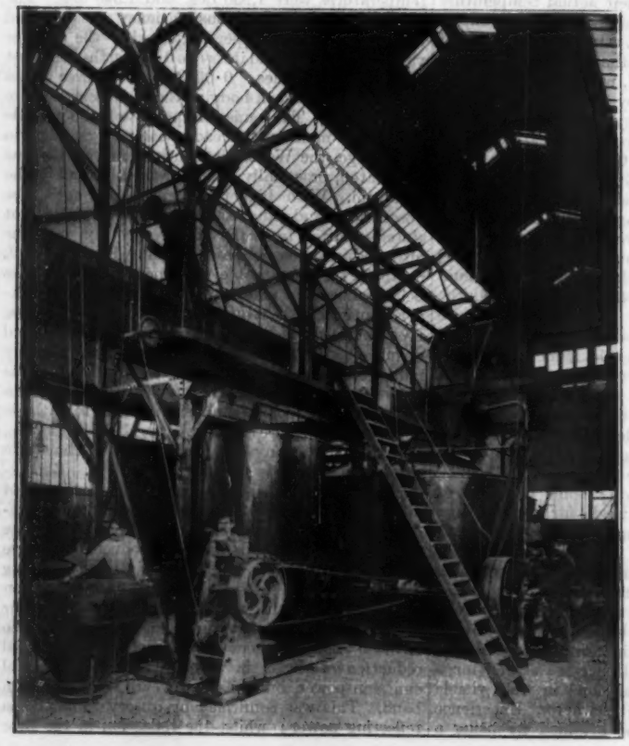


FIG. 2. PUTTING SODA IN THE HOPPER

FIG. 4. STARTING THE WATER SUPPLY PUMP.

THE BRITISH ADMIRALTY HYDROGEN GAS PLANT.

CONSTRUCTED BY THE SOCIÉTÉ L'OXYLITHE, PARIS.

FIG. 5. TURNING THE SILICO SPIEGEL FOR USE IN THE PLANT.

dropped, in the flame, down to one-fifth of its value in the cold, it was little diminished by the kathode bombardment. Further tests made were with mantles heated in vacuo, in which ceria turned yellow as in air flames, and also with heating the mantles in hydrogen, which was first burning in air the latter being then replaced by chlorine (in which the hydrogen continues to burn); the brilliancy of the various mantles did not change. The conclusion is drawn that the two absorption bands due to ceria, the one in the blue, the other in the infra red, are separately developed, and that the former is inhibited only by a very strong reduction, whilst the latter is more easily increased by a non-oxidising condition.

We briefly mention the many measurements made on mixtures of thoria and various other oxides. Uranium oxide, black itself, turned brown and pale yellow in the hot mixtures with thoria, and the mantles showed two efficiency maxima, for 0·35 per cent. and for 1 per cent. of uranium oxide, but did not bear prolonged heating; otherwise uranium oxide was the best substitute for ceria found. The oxides of manganese and nickel gave little promise. Lanthana resembled ceria more, but only when used in high percentages. Neodymia, distinguished by its sharply-defined absorption bands, gave like praseodymia with the white thoria brown mantles (though itself pink), which turned colourless on heating, and displayed interesting peculiarities. None of these oxides, or others tested (of iron, titanium, molybdenum, tungsten, zinc strontium, barium, &c.) could rival ceria, however.

We come back to the general consideration of the two variables at our disposal, mantle temperature and composition. The temperature attainable in the Bunsen flame, about 2,100 deg. C. absolute, is very low for light production; yet as the temperature rises from 1,900 deg. to this value, the luminous radiation increases already threefold, and at 3,000 deg. (the temperature of the nitrogen-filled tungsten lamp) it should be 30 times as great. But the mantles would not bear much higher temperatures. If we could, however, burn gas and oxygen in our lamps, we should gain the additional advantage of avoiding the useless heating of large volumes of nitrogen. At the ordinary mantle temperature 75 per cent. of the energy supplied to the lamp is lost in this way; if the temperature were lowered to that the ceria mantle (1,350 deg. C.), the loss would be only 45 per cent. We might also save a great deal if we could heat the mantles in vacuo. Keeping to the actual Bunsen flame and the thoria base, however, Ives, Kingsbury and Karrer calculate that a very substantial increase in the luminous efficiency—to 13 per cent.—might be realised, if we could find a colorant superior to ceria, which would have to differ from ceria in having the absorption band sharply defined on the red side (like neodymia) and not gently sloping away, while adding nothing to the radiation near 2 μ in the infra red; that would mean an increase in the emissive power near 0·6 μ in the yellow-green, at the expense of the radiation in the visible red. The total luminous efficiency of the burner and lamp might then be raised to 2·6 per cent., which is 13 times that of the actual gas mantle, whilst yet below the actual efficiency of the tungsten lamp, 3·2 per cent. In this last estimate, however, allowance is not made for the conversion of the coal energy into electricity, and the two types of lamps would differ very little in efficiency finally.

There is little guidance so far as to the way in which that ideal mantle might be obtained. Many people do not wish for much more brilliant gas burners, moreover, at any rate in their houses. The Nernst burner, which is less sensitive to high temperature than the gas mantle, enjoys little general favour. It might possibly be simplified and made more reliable; but this side of the problem is not alluded to by Ives and his collaborators.

THE BRITISH ADMIRALTY HYDROGEN GAS PLANT.

THE Admiralty put down, a couple of years ago, the first of a series of stations for dirigible balloons of the non-rigid type manufactured by Messrs. Vickers, Limited. For supplying these dirigibles with hydrogen, the Admiralty contracted with the Société l'Oxylithe, a French firm which had built for the purpose a very effective type of generator. Fig. 1, page 102, illustrates the first set of apparatus supplied to this country by the French firm in question. It was guaranteed to produce 1,500 cub. m. (52,975 cub. ft.) per hour; at the official tests it yielded 1,700 cub. m. (60,035 cub. ft.), having a lifting power of 1,180 grammes per cubic metre (0.073 lb. per cubic foot).

The plant operates the Jaubert process, styled the silicol process, which consists in the decomposition of silicon alloys obtained in the electric furnace, such as ferro, or mangano-silicon, or even ferro-spiegel, by a concentrated solution of caustic soda (35 per cent. to 40 per cent. of NaOH). In the silicol process, the silicon alloys are made to act on a caustic alkali solution having a high boiling-point, the object being to retain in the solution itself all the heat generated by the reaction in the combination of the silicon with the alkali, thus doing away with all outside heating.

The installation contains a vat provided with a stirring device for preparing the caustic soda solution. The lower part of the vat is fitted with a pipe provided with a valve and ending in a gas generator; the latter is fitted with a "planetary stirrer," and has at its top part a receiver containing the silicon alloy. The receiver has a hopper-shaped base in which acts a distributor worked by a crank.

The plant operates as follows. Soda in lumps, in pieces of cylindrical shape or in slabs, is put in the vat, to the extent of one and a-half times or double the weight of soda to that of water; the stirring device is started running and the dissolution of the soda takes place, the heat thereby evolved being sufficient to raise the temperature to about 60 deg. or 80 deg. C. The solution is then led into the gas generator, which, it should reach at a temperature sufficient to start the reaction on contact with the silicon alloy. The "planetary stirrer" causes the silicon alloy powder falling from the hopper-shaped base of the receiver to come into intimate contact with the caustic soda solution, and prevents it from accumulating in the centre of the generator. The hydrogen gas, which is evolved at a high temperature, flows into a scrubber-condenser, where it loses the water vapour it contains and is cooled at the same time. The hydrogen gas then flows out through a pipe for utilisation. Fig. 2, shows the soda being put into the hopper shown to the left of the view, the hopper being then raised and placed in the vat. Fig. 3 shows the water gauge; Fig. 4 the starting of the water pump, and Fig. 5, on the present page, the turning of ferro spiegel preparatory to its utilisation in the silicol process.

The water used for cooling the gas in the scrubber-condenser, which leaves this at a temperature close upon boiling-point, is recovered, and is utilised in the vat or in the gas generator as needed.

The advantages of the silicol process lie in the use of a silicon alloy in which the cost of the unit of silicon is a low one compared with that of the industrially pure silicon hitherto used for the same purpose, this leading to a great reduction in the cost price of the hydrogen gas. In installations where a weak solution of caustic soda is used, a neutral silicate of soda is formed, whilst when working, as is the case in the plant we illustrate, with a concentrated solution, an acid silicate poorer in soda is obtained; this leads to a saving in caustic soda and allows the obtaining of non-caustic residues which can be utilised for dyeing and bleaching.

The water-gauge can be suitably connected to the powdered silicon alloy distributor so as to cause the delivery of the alloy powder to vary automatically with the consumption. The alloys which have given good results are the various grades of ferro-silicon, mangano-silicon and silico-spiegel. One single silicol plant of the type referred to can fill in half a day the largest type of dirigible.

The same company, the Oxylithe Company, themselves prepare hydrogen gas by the electrolytic process, and we illustrate in Fig. 6, on page 104, a portion of their electrolysis room for that purpose; whilst Fig. 7, on the same page, shows the delivery of cylinders charged with hydrogen gas.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Eng. Vice-Admiral G. G. Goodwin, K.C.B., R.N., and Sir Aubrey Strahan, K.B.E., LL.D., F.R.S., have been elected honorary members; A. E. Dunstan D.Sc., F.C.S., and W. R. Ormandy, D.Sc., F.C.S., have been elected members of Council of the Institution of Petroleum Technologists.

PLANT FOR THE MANUFACTURE OF HYDROGEN BY ELECTROLYSIS.

(*For Description, see Page* 103.)

FIG. 6. VIEW IN ELECTROLYSIS ROOM OF THE OXYLITHE COMPANY FOR THE PREPARATION OF OXYGEN BY THE ELECTROLYTIC METHOD.

A MACHINE FOR MEASURING SCREWS.

By P. E. SHAW, B.A., D.Sc., University College, Nottingham.

1. *Preliminary.*—The war has given a great impulse to precision work in this country. Particular attention has been assigned to screw gauges, the manufacture and exact measurement of which have presented unusual difficulties. Munition screws, plug and ring, are so varied in size and type that their name is legion. And it has been a triumph both for engineers and metrologists to raise this branch of the subject from its state of neglect, four years ago, to its present high level.

This article deals with the metrology of precision screws, in which we owe much to the many useful inventions produced at the National Physical Laboratory during the war. These are now well known and have been described in previous issues of ENGINEERING.

But, happily for the inventor, much still remains to be done, and there are screw problems awaiting solution. Especially is this so as regards ring screws. In the case of an ordinary ring screw, cut on the inside of a cylinder, the standard method of determining full, effective, and core diameters is to use a series of "checks" of plug form, whose dimensions have been very accurately verified.

For any ring screw a complete set of checks consists of a "go" and "not-go" cylindrical plug, a full-form plug screw, and four specially-made screw-form plugs truncated suitably to bear either on the slopes or at the root of the ring screw. That is, we require, in all, seven checks. After applying the whole series to the ring we are able to state its diameter, correct to somewhere between 0·5 mil and 1 mil (1 mil = 1/1000 in). But unfortunately this is not accurate enough for master gauge purposes.

In the case of plug screws we demand, and we get, accuracy of a higher order, *i.e.*, to 0·1 mil; so that our master plug screws are, say, five times as accurate as our master ring screws. Now rings are as important as plugs in any system of standardisation, and it is obvious that precision in screwed work is held back at present by the inaccuracy which we are forced to allow in the rings.

FIG. 7. DELIVERY OF HYDROGEN CYLINDERS.

Further, the present method involves the expenditure of a large sum of money on the many checks required. Checks are perishable; and when they

wear out with use or get otherwise damaged, considerable loss of time is involved in their replacement. In short, the present system is artificial and uneconomical, and is surely destined to extinction. The shortcomings of our present method were admitted by Sir R. Glazebrook (see British Association, 1916) in his paper on Gauges, when he said: "A simple and rapid method of measuring internal diameters, especially of small screws, is much to be desired." The best way to take measurements on any solid surface, screwed or otherwise is: not as in the "check" method to attempt to fit one complex surface on another; but to use the simplicity and certainty involved in point contact. When a check "fits" a ring it is impossible to say at what point or points the surfaces bear, and we cannot hope ever to gain accurate information when there are so many unknown quantities in one equation.

The methods to be now described depend on the use of simple point contact in all cases, for plugs and rings alike, whether cylindrical or tapered. By this means we obtain appreciably equal accuracy for all kinds of screwed work. The machine used, which deals with the diameters and the pitch, is of a simple type and easy to use.

2. *The Machine as Used for Plug Diameters.*—A solid bed A, Figs. 1 and 2, rests on three feet, of which one is shown. The sides are each about 36 in. long, 3 in. high and 1 in. thick; the top of one is plane, that of the other, the nearer, is grooved to a V. On the bed rests a table T, provided with three legs L', L, L. The first of these rests in a triangular hole in an end plate E, while the others stand on the two sides of the bed. The top surface of the table is similar to that of the bed, viz., the near side grooved, the far side plane. These surfaces are machined and scraped true. On the table is a rectangular carriage C, having three rounded brass feet, resting two on the grooved top, and one on the plane top surface. On the carriage is a beam B (shown only in Fig. 1). On the under side of the beam are soldered two ½-in. steel balls. One of these balls rests on a triangular hole R, the other on a slot V on a cross-bar fixed to the carriage. The left end of the beam carries a pin P_1; its right end another pin P_2. The former pin bears on the screw, Sw, undergoing test; the latter supports the left end of an optical lever Le. Some details of this lever are shown (Figs. 3 and 4). A frame *b*, carries a hard steel plate *a*, whose bottom face is ground flat, and in front a circular case *f*, holding a mirror M_1. Soldered to the under side of the frame are two small steel balls which play the same part as the steel balls already mentioned in the beam. They rest, one on a triangular hole, the other on a slot in the upright blocks, K_2, K_2, attached to the carriage.

Fixed to the carriage (Figs. 1 and 2) is an aluminium girder G, with an adjustable scale Sc, near its end. The centre pins Ce, Ce, in the standards S, S, carry the plug screw Sw, under test.

By the above arrangements we provide a rigid bed and table; having a carriage and scale free to slide along the table; while the beam and lever are, in addition, free to rotate on a horizontal axis as the pin P_1 moves up or down on the screw Sw. By adopting throughout the machine the perfect geometrical fit provided by a triangular hole, slot and plane, we ensure freedom from looseness, whilst the machine can be taken to pieces rapidly. The beam is cranked so as to allow the vital points to lie in the same horizontal plane. We thus have in one plane the working ends of pins P_1, P_2, the centres of both balls on the beam and of both balls on the lever, the centre of mirror M_1 and, lastly, the mean position on the scale Sc. By thus disposing of all these cardinal points, we obtain normal action at the contact ends of P_1 and P_2; and there is no appreciable sliding, for instance where P_2 bears on the lever, providing the up-and-down movement of P_2 is small.

One peculiarity of the machine is that, when the carriage moves, it takes with it, rigidly connected, the beam, the lever, both mirrors M_1 and M_2, the telescope Te, and the scale. By this arrangement only one observer is required, and we avoid change of focus and all relative movement in the vital parts. Thus as the carriage, and all it bears, slides along the table we shall be able to measure all threads of the screw on exactly the same basis.

3. The action of the machine is as follows: Having set P_1 on any desired part of the screw top, say on a crest, we take a scale reading through telescope Te. Next we move P_1 to another place, say an adjoining root. To attain this we slide the carriage along the table. P_1 will move down, and a new scale reading will be taken corresponding to the angular movements of beam and lever. The machine having been previously adjusted so that one scale division corresponds to a vertical movement by P_1 of 1 mil (= 1/1000 in.), we at once ascertain the vertical distance between crest and root, that is, the depth of thread. The scale readings are divisible by eye to tenths; hence we take these distances to 0·1 mil, a degree of accuracy which is required in the best measurements of diameter.

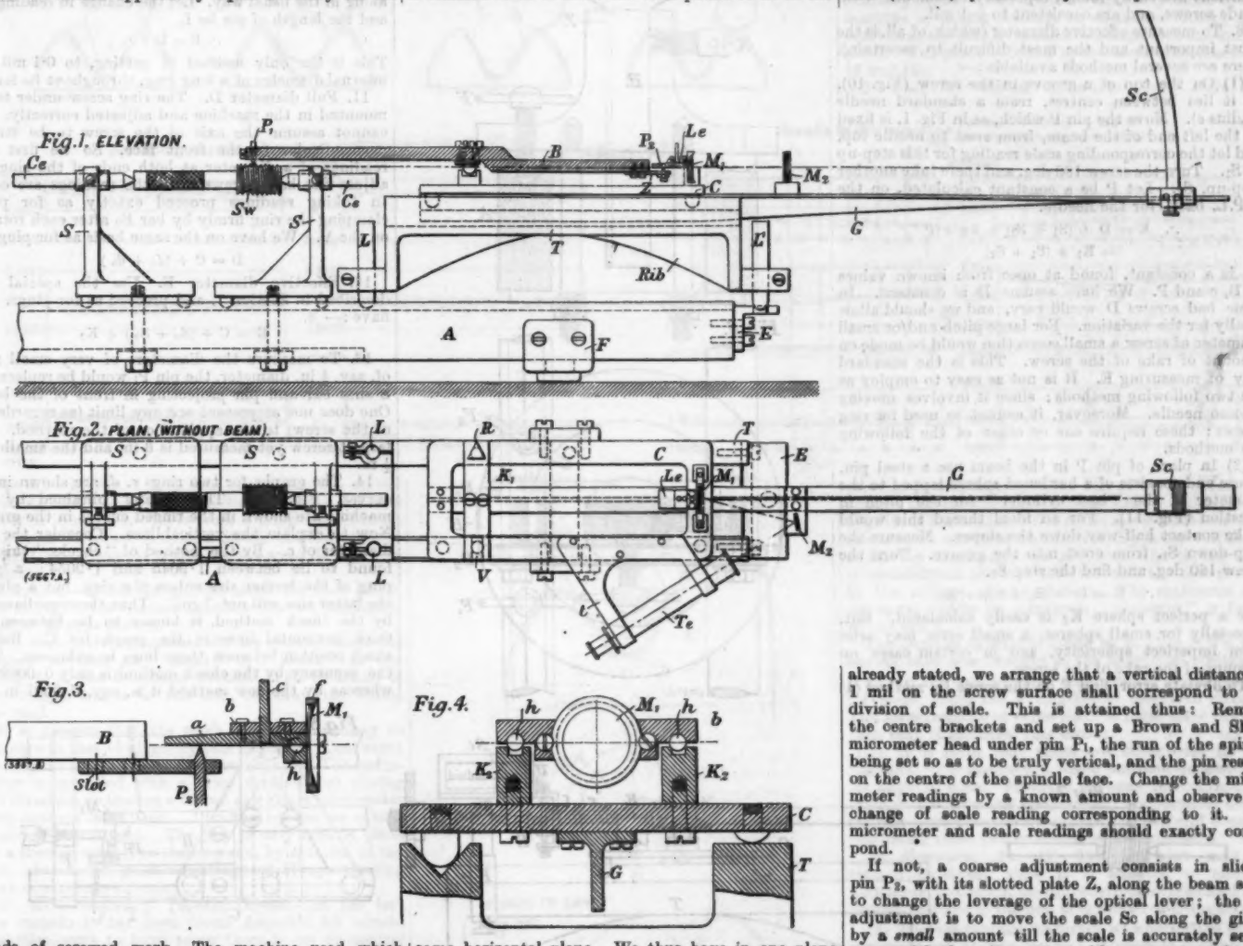
4. In order to bring the V groove of the table into alignment accurately with the line of the centres, we have one adjustment for it in azimuth, another in elevation. Without these adjustments we might, in sliding the carriage on the table, run the pin P_1 athwart the screw axis, introducing error in the results, especially for screws of small diameter. The azimuth adjustment is made by moving the slotted plate E to or fro' across the bed; the elevation adjustment is made by changing the length of leg L'. The accuracy with which the adjustments are made is easily ascertained; but to save space details are omitted.

There are advantages in having only a low magnification (40-fold) produced by the optical lever. As already stated, we arrange that a vertical distance of 1 mil on the screw surface shall correspond to one division of scale. This is attained thus: Remove the centre brackets and set up a Brown and Sharp micrometer head under pin P_1, the run of the spindle being set so as to be truly vertical, and the pin resting on the centre of the spindle face. Change the micrometer readings by a known amount and observe the change of scale reading corresponding to it. The micrometer and scale readings should exactly correspond.

If not, a coarse adjustment consists in sliding pin P_2, with its slotted plate Z, along the beam so as to change the leverage of the optical lever; the fine adjustment is to move the scale Sc along the girder by a *small* amount till the scale is accurately set to agree with the micrometer. After correct setting we find that the micrometer and scale keep in perfect correspondence over a long range.

5. This range, which depends on the relative lengths of beam, lever, etc., is in the machine, as above described, about ½ in.; and it is quite sufficient for ordinary screws. But for very coarse threads a simple additional device, not shown in the diagrams, is provided. A pin P_3 is fixed in the right end of the beam; and is adjusted so that its point is exactly as far as P_1 is from the axis on which the beam turns. Also adjustment is provided by which the points P_1 and P_3 are in the same horizontal plane as the pivotal axis of the beam. Over P_3 is mounted a micrometer head with its spindle set truly vertical. Thus the movement of the point of P_3 is always equal to that of P_1, even when this amounts to say ½ in. And this movement is accurately read on the micrometer head.

6. *Procedure for Plug Diameters.*—To measure full diameter, D, place the plug in the well-known N.P.L. machine (which has a floating micrometer accurately aligned across its axis). Use a standard cylinder to set the micrometer and thence find diameters in several places. A common practise is to use a loose micrometer, but it will be found that this often gives



slightly smaller readings than does the above method. The loose micrometer, in moving over crests which vary in height, will incline its axis to conform to these variations. Now if a ring screw be threaded on the plug it will not incline to and fro' for any variation of crests. If the crests bear at all, only the highest will do so, as occurs when we measure with the N.P.L. machine. Surely the ring screw provides the true criterion, and we thus prefer the method given.

7. To measure core diameter C use a taper pin with the point just rounded (Fig. 9). Observe the change in scale reading as the pin is moved from crest to root at several places on the screw axis. For each place record the readings d_a, d_b, at 0 deg. and 180 deg. round the screw:

$$\therefore \quad C = D - (d_a + d_b)$$

In taking readings the observer looks through the telescope and, placing a hand at each end of the carriage, moves the latter to and fro' to obtain maximum reading, for crest and minimum for root. These positions are easily found, especially on smooth, well-made screws, and are consistent to 0·1 mil.

8. To measure effective diameter (which, of all, is the most important and the most difficult to ascertain), there are several methods available:—

(1) On the top of a groove in the screw (Fig. 10), as it lies between centres, rests a standard needle (radius c). Move the pin P which, as in Fig. 1, is fixed at the left end of the beam, from crest to needle top, and let the corresponding scale reading for this step-up be S_1. Turn the screw 180 deg. and there take another step-up, S_2. Let P be a constant calculated, on the N.P.L. basis, for the needle.

$$\therefore \quad E = D + (S_1 + S_2) - 4c + P$$
$$= K_1 + (S_1 + S_2)$$

K_1 is a constant, found at once from known values of D, c and P. We here assume D is constant. In some bad screws D would vary, and we should allow locally for the variation. For large pitch and/or small diameter of screw a small correction would be made on account of rake of the screw. This is the standard way of measuring E. It is not as easy to employ as the two following methods; since it involves moving a loose needle. Moreover, it cannot be used for ring screws: these require one or other of the following pin methods.

(2) In place of pin P in the beam use a steel pin, whose end consists of a hardened sphere lapped to the diameter of the "best cylinder" for the pitch in question (Fig. 11). For an ideal thread this would make contact half-way down the slopes. Measure the step-down S_1, from crest into the groove. Turn the screw 180 deg. and find the step S_2.

$$\therefore \quad E = D - (S_1 + S_2) + K_2$$

For a perfect sphere K_2 is easily calculated. But, especially for small spheres, a small error may arise from imperfect sphericity, and in certain cases on account of the rake of the screw.

To obviate error, find E on the screw by method (1) above, and substitute its value in the last equation. Then measure S_1 and S_2 by the pin method and we ascertain K_2 exactly, once for all, and use this value on all future plug or ring screws of this pitch.

(3) Another way is to use a pin whose diameter is lapped down to exactly half the pitch of the screw, the bottom of the pin being finished spherical as shown (Fig. 12). Here again the pin makes contact, on an ideal screw, half-way down the slopes. Proceed as in method (2) to find S_1 and S_2.

$$\therefore \quad E = D - (S_1 + S_2) + K_3$$

Determine the constant K_3 by appealing as before to method (1). Thenceforward for plug or ring screws of this pitch use this pin method direct.

Of the last two methods (2) is the better. For if we can obtain very true spherical ended pins we need make no appeal to the wire method (1), except in special cases where rake error is appreciable. But the pin of half-pitch diameter is very readily obtained on an emergency, whereas the sphere-ended pin is difficult to make.

The graphs for two plugs, a, b are shown in Fig. 13, where D, E, C are, respectively, the full, effective, and core diameters. As will be seen the results by the new and old methods are in agreement within the limits of experimental error. For E and C there should be four curves. If less than four are shown in the graphs it is because two or more are coincident.

Fig. 5.

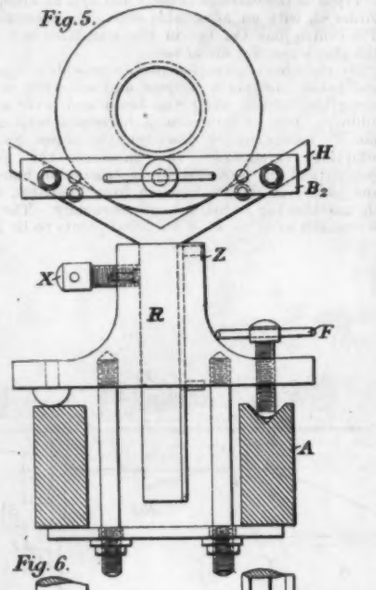
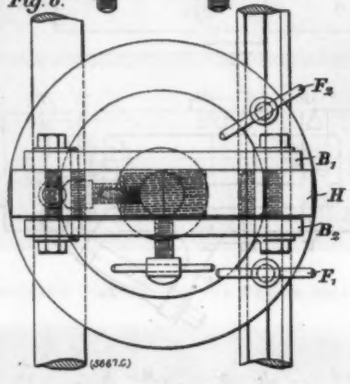


Fig. 6.



9. *Modification for Ring Diameters.*—Replace the standards S, S (Fig. 1), by a special ring carrier (Figs. 5 and 6) which can accommodate rings of any size up to 8 in. diameter. This carrier is clamped to the bed A, as shown. A V-holder has bars B_1, B_2, clamped to it, front and back. The former is screwed hard up to the V; the latter is screwed up till it holds the ring firmly in place.

There are two motions of the V holder. Its supporting bar R slides up and down in the casting Z below, and can rotate to any azimuth and be clamped there by screw X. A key is sometimes fitted to the bar to ensure correct azimuth.

Three conditions are necessary for accuracy: (1) The imaginary line, formed by the two flat upper faces of the V, must be horizontal. (2) This line must also be parallel with the line of run of the table. (3) It must also lie exactly under the point of pin P_1 (Fig. 1) throughout the run of the latter, as the carriage slides on the table.

To attain the first and third conditions, we have two screws F_1, F_2, acting as feet and resting in the front, grooved, plate of the bed. If both F_1 and F_2 be screwed inwards the bottom of the V is thrust across the bed under the pin P_1; but if one be screwed in, the other out, the V will change its inclination to the horizontal. Lastly, by rotating the V on its axis we attain the second of the above conditions.

10. *Procedure for Ring Diameters.*—Core diameter C. There is an instrument made by Brown and Sharp, the inside micrometer calliper, for measuring the inside of a cylinder. It has cylindrical measuring jaws and shows core diameter of any place in the ring to 1/10 mil. Lacking this special calliper, one can use Johansson gauges wrung together with special jaws.

But a better method than either of these is rendered possible by this machine as follows:—In place of P_1 (Fig. 1) mount a long pin, of length slightly less than C, the core of the ring. Both ends of this pin are pointed. First bring the top end of the pin to touch the top end of the core; take a scale reading. Next bring the bottom end of the pin to touch the bottom of the core; take a second reading, sliding the carriage along in the usual way. Let the change in reading be r and the length of pin be L,

$$\therefore \quad C = L + r.$$

This is the only method of getting, to 0·1 mil. the internal diameter of a long ring, throughout its length.

11. Full diameter D. The ring screw under test is mounted in the machine and adjusted correctly. We cannot assume the axis of the screw to be strictly perpendicular to the front face. So we first take readings of a diameter at both ends of the ring and adjust the base screws until the readings are equal. In taking readings proceed exactly as for plugs, clamping the ring firmly by bar B_2 after each rotation on the V. We have on the same basis as for plugs:

$$D = C + (d_a + d_b)$$

12. Effective diameter E. Use the special pins described in Section 7, and proceed as for plugs. We have:—

$$E = C + (S_a + S_b) + K_2$$

13. To measure the diameters of very small rings of, say, $\frac{1}{4}$ in. diameter, the pin P_1 would be replaced by a slim bar and pin projecting in front of the beam. One does not at present see any limit (as regards size of the screw) to the application of the method. The largest screw yet measured is 8 in. and the smallest is $\frac{1}{4}$ in.

14. The graphs for two rings c, d, are shown in the curves, Fig. 13. The results obtained by this machine are shown in the ringed curves in the graphs. Now to explain the vertical lines. Consider the core diameter of c. By the method of "checks" this was found to lie between 1·9045 and 1·9054; a plain plug of the former size enters the ring, but a plug of the latter size will not "go." Thus the core diameter, by the check method, is known to be between the thick horizontal lines in the graph for C. But its exact position between these lines is unknown. Thus the accuracy by the check method is only 0·0009 in.; whereas by the new method it is, say, 0·0001 in.

Fig. 7.

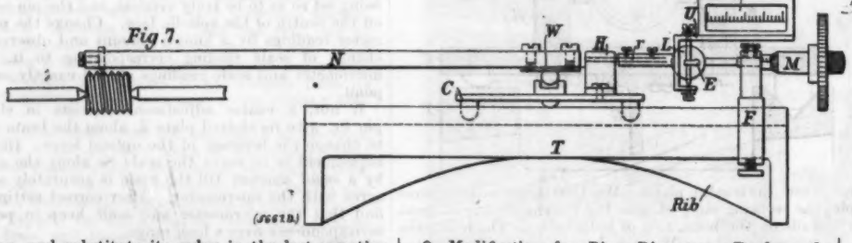
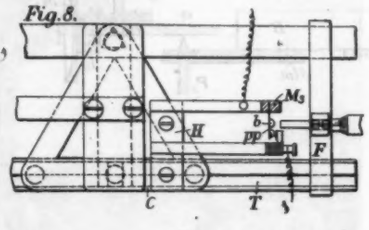


Fig. 8.



As regards effective diameter, E. A full-form plug screw 1·9502 enters the ring with "good fit" therefore a line is drawn at this place.

In the case of the full diameter D, a special full-form plug of 1·9960 enters the ring. The actual clearance is found by the new method to be about 0·0002 in.

On comparing the graphs in Fig. 13 for plugs and rings we see how unfavorably the accuracy of the latter compares with that of the former by the old methods.

15. *The Machine as Used for the Pitch of Plugs and Rings.*—By a modification of the machine we measure pitch. Remove the carriage of Figs. 1 and 2, and substitute a smaller carriage C (Figs. 7 and 8). On the carriage place beam N and attach to the table the micrometer head M, by the bracket F. The beam like that of Figs. 1 and 2, has steel balls for feet, resting in triangle and slot, in the carriage. The beam acts as a firm coupling between the screw under test and the carriage. The principle of action is to rest the pin, at the left end of the beam, in a groove of the screw, and press the beam down to ensure exact seating every-

where. Then advance the micrometer to make contact with the carriage. Read the micrometer. Repeat these operations as the pin moves from groove to groove. We thus measure the pitch.

16. It is necessary to measure pitch to 0·01 mil: thus some delicate indicator is needed to show when the spindle of the micrometer touches the carriage. Two simple indicators, one optical and one electric, are shown.

Of these, the second is much the better, and has been finally adopted. The optical method is shown on the machine in elevation; the electric method on part of the machine in plan. The details are as follow:

Optical.—In Fig. 7 it is seen that when the micrometer spindle touches the rounded bar E the concave mirror L is rotated. Rays from a lamp are reflected from L and afterwards from a distant mirror, and are brought to a focus on a translucent scale Sc near the observer.

Electrical.—When the spindle meets the steel ball *b*, seen in Fig. 8, the contact between the two plantinum surfaces *p*, *p*, is broken.

The electric circuit consists of a dry cell and telephone receiver so that on "make" or "break" at the points *p*, *p*, the telephone sounds. This indicator is very simple and is far the best, of many, the writer has used.

It is obvious that the pitch of rings is as easy to measure as that of plugs, by this machine. Consistent readings to 0·02 mil can be taken always. The micrometer is provided with a loose divided disc having 250 divisions, so that on a Brown and Sharp micrometer each division is 0·1 mil. Dividing by eye we obtain readings of 0·01 mil. The disc is only held in place by a friction spring, so that we can, by rotation of the disc, obtain the great advantage of always starting a set of readings at zero.

17. *Measurement of Tapered Screws.*—In the last few months it has been found desirable for certain munition work to have screw threads cut on conical plugs or conical holed rings. These are cut in two ways: either square to the axis, or square to the surface of the generating cone.

18. *Case I. Thread Square to Axis.*—In the Fig. 14 is shown the profile of two threads formed by a section through the axis. Dotted is shown the usual cylindrical form of screw of the same pitch *p*.

If a cylinder of best diameter ($= \frac{p}{4} \sec \alpha$, when $\alpha =$ the half angle of the thread) were placed in the usual thread it would rest as shown dotted with centre A, making contact half-way down the flanks. The same cylinder placed in the taper thread has its centre at B, having moved from the first position a distance A B parallel to the long sloping flank.

If β = half angle of taper, r equals radius of cylinder, d = depth of thread ($= \frac{p}{2} \cot \alpha$) of the usual cylindrical screw, we have the vertical component of A B

$$= A C = \frac{p}{2} \tan \beta.$$

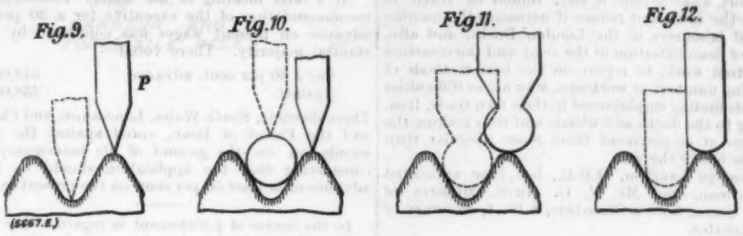
In the usual screw the vertical distance from the line of the crests to the top of the cylinder is

$$h' = r(1 + \tan \alpha) - \frac{d}{2}.$$

In the taper screw we deduct $\frac{p}{2} \tan \beta$, as shown above; so the distance in this case is

$$h = r(1 + \tan \alpha) - \frac{d}{2} - \frac{p}{2} \tan \beta.$$

For the ideal taper screw we should find this distance on the machine by measuring the vertical distance from Cr to the line N N. In practice any error in the effective depth would be revealed in this determination of *h*. The machine is worked in the usual way, the axis of the taper screw being held between horizontal centres.



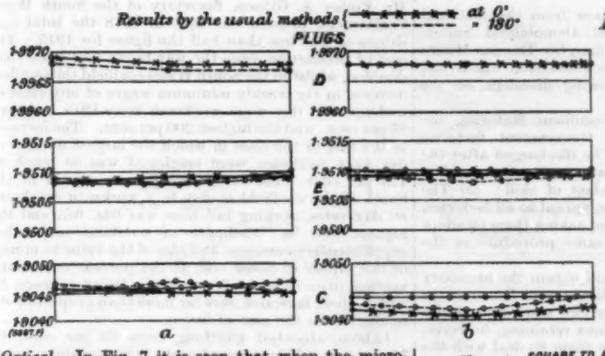


Fig. 13.

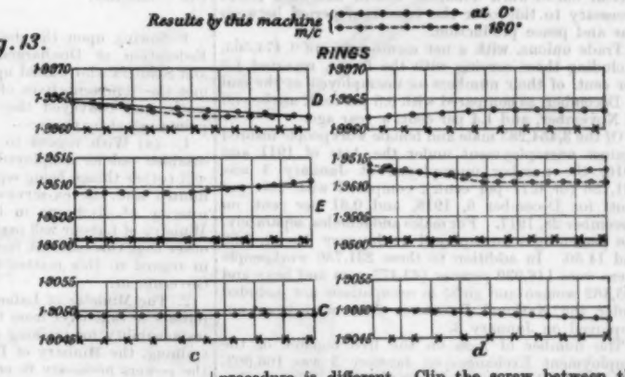


Fig. 14 SQUARE TO AXIS.

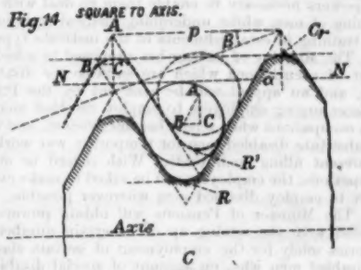
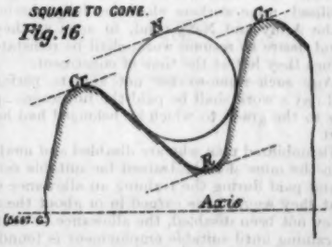


Fig. 15.

SQUARE TO CONE.

Fig. 16.



19. Similarly the root R of the taper screw is seen from the figure to be at a vertical distance below the root R', of the usual screw by the same distance, A C $= \frac{p}{2} \tan \beta$. Hence for the ideal taper screw the drop from Cr to R $= d + \frac{p}{2} \tan \beta$ and we should measure the drop in the usual way by the machine.

Combining the above values for effective depth and full depth of thread with information obtained by optical projection of the screw, we shall know in all respects how truly the threads are cut.

20. Next we must find the lateral dimensions of the taper screw. It must be remembered that if the threading were projected on a plane perpendicular to the axis, it would form an Archimedean spiral (see figure 15). Thus the word diameter for taper screws is a misnomer, since the radius of the threading changes uniformly as we pass along the axis. We may, however, measure the maximum and minimum radius of the screw surface.

Consider the large end of the taper screw. Let the terminal point of the crest, where it becomes the surface, be M. Go back 45 deg. and measure with a micrometer the distance A B across the threads. Measure also C D, a further 45 deg. back.

$$\therefore 2AB = MN + CD$$

$$MN = 2AB - CD$$

$$MO = (2AB - CD) - ON = (2AB - CD) - CD/2$$

M O is the maximum radius of the screw. It cannot be found directly. If the maximum "diameter" M N is desired, we have it as above. The minimum radius and "diameter" at the far end of the screw are similarly found. The angle of taper β is found on the machine by taking readings on successive crests; and combining the results of these readings with the known pitch. The pitch is found in the usual way (Sections 15 and 16.)

21. *Case II. Thread Square to Cone.*—Here the procedure is different. Clip the screw between the centres and tilt the screw till the line of crests Cr, Cr, Fig. 16, is horizontal. When the screw surface is thus disposed we can measure effective depth and full depth as for the usual screw surface, since the thread form is symmetrical about a line through the root normal to the surface of the threads. The maximum and minimum radius or maximum "diameter" is found as in Case I.

The angle of taper β is found as in Case I, the axis having been now brought to the horizontal position.

22. In the case of taper ring screws, we proceed as for plugs, using the V ring-holder described already. The measurement of these rings is little more difficult than that of the usual ring screws.

23. It is clear that there are other uses for the machine. For instance, a coned plug can be measured for angle of cone. Mounted between the centres, our pitch device measures abscisse and the diameter device measures ordinates. We obtain the angle of cone by combining these two co-ordinate measurements.

24. *Summary, &c.*—(1) This machine may be termed universal, since it is adapted to measure diameters and pitch, of ordinary plug screws and ring screws, and also of tapered plug screws and ring screws.

(2) The outstanding feature is its application to the measurement of ring screws; it renders possible the measurement of these to 0·1 mil, which is the accuracy attainable for plug screws. This method of measuring ring screens is at once much cheaper and much more accurate than the usual method of checks.

(3) The principle of the machine as regards measurement of diameters is to actually measure the full depth and the effective depth of thread; also to measure by usual or special means the full diameter for a plug, the core diameter for a ring, and subtract or add, respectively, the depth measurements to obtain the other two diameters.

(4) The principle employed for measuring pitch is an adaptation of the machine, in which the method of electric touch is employed. This is simple and is reliable to 0·02 mil.

(5) The machine is arranged so that adjustments and calibration can readily be made. One advantage of the method is that the pressure at the measuring points is slight and wear of the surfaces is reduced to a minimum.

(6) The machine, as described, has a great range of usefulness as to diameters and pitch. One sees no limit to its applicability to screwed surfaces of whatever size or shape.

25. I wish to express my gratitude to the Scientific

and Industrial Research Department, for providing me, for the purposes of this work, with an assistant, and with funds for apparatus in 1916. Mr. W. H. Turner, B.Sc., ably assisted me for six months in this work, but then left for the Front. Thus, almost the whole development of the machine has devolved on me.

Our national indifference to research and to progress in scientific matters has cost us dearly in the last four years. Now our statesmen have come to realise that, under the conditions of this century, the nation which neglects pure and applied sciences will fail to secure either prosperity or safety. The rewards in the immediate future will be to those nations which acquire trained intelligence and which foster imagination. Precision has come to us as a by-product of the war; and we have an unparalleled opportunity to utilise and improve, for the purposes of peaceful pursuits, this new skill, so recently developed.

INDUSTRIAL NOTES.

WE read in *The Labour Gazette* for the present month that there was a marked decline in the general state of employment in December, especially in the case of women. The trades directly connected with war requirements were, of course, most affected, and a special out-of-work donation benefit has been found necessary to tide over the transition period between war and peace production.

Trade unions, with a net membership of 1,174,565, excluding those serving with the forces, reported 1.2 per cent. of their numbers as unemployed at the end of December, as compared with 0.5 per cent. at the end of November, and 1.4 per cent. a year ago.

Of the 3,454,283 male and female workpeople insured against unemployment under the Acts of 1911 and 1916, the number unemployed at January 3 was 231,756 (or 6.71 per cent.), compared with 2.54 per cent. for December 6, 1918, and 0.81 per cent. on December 28, 1917. For males and females, separately, the percentages unemployed at January 3 were 3.89 and 14.50. In addition to these 231,756 workpeople there were 148,939 persons (43,477 men and boys and 105,462 women and girls) in occupations not included under the National Insurance Acts who were unemployed on January 3.

The number of men on the live register of the Employment Exchanges on January 3 was 166,603, and the number of women was 279,078. The number of vacancies notified during the week ended January 3 was 14,163 for men and 13,079 for women, and the number of vacancies unfilled at the end of the week was 73,740 for men and 39,510 for women.

Employment at coal mines continued good, and there was an increase of nearly 3 per cent. in the number of workpeople employed at the collieries making returns, while the average number of days worked per week by the collieries was 5.75, or about the same as in October. (The figure 5.34 for November was affected by armistice celebrations.) At iron, shale, and tin mines employment was good, though not quite so good as in November. It continued good at lead mines. At quarries it was fairly good on the whole, but work was interrupted by wet weather.

In the pig iron industry employment continued good, but some furnaces were blown out, in part owing to shortage of fuel and in part for repairs. Employment at iron and steel works was good, but the pressure was not so great as in the previous month, and there was some reduction in the number of men employed.

The stoppage of much war work had a marked effect on employment in the engineering and allied trades. On the whole it was fairly good for men in these trades; there was not much overtime, but, on the other hand, little short time. In the shipbuilding trades employment continued good, though there was less overtime. At tinplate and steel sheet mills it was good, but there was still some shortage of steel. In most of the other metal trades employment remained good on the whole in December, but there was some decline owing to the reduction of Government work.

The changes in the rates of wages (including war bonuses) reported to the Department as having been granted in December resulted in an aggregate increase of nearly 600,000*l.* in the weekly wages of over 2,000,000 workpeople. The principal changes included in these figures were increases of 5*s.* and 2*s.* 6*d.* per week to men and boys respectively, in the engineering and shipbuilding trades, and an increase of 50 per cent. on list prices to workpeople in the cotton industry. The increases in the engineering and shipbuilding trades were also applied to men and boys in various other metal trades, including railway wagon building, light castings manufacture, and the tube, brass, sheet metal, and nut and bolts trades, and also to those employed in the chemical and explosives trades, and in the aircraft woodworking trades. Other important increases granted during the month affected iron and steel workers in the Midlands.

The number of trade disputes beginning in December was 51, and the total number of workpeople involved in all disputes in progress was about 150,000 (including 100,000 cotton spinners, &c., in Lancashire and Cheshire, who ceased work for nine days), as compared with 55,000 in the previous month, and 77,000 in December, 1917. The estimated duration of all trade disputes during the month was 1,174,000 days, as compared with 251,500 days in November, 1918, and 258,000 in December of last year.

A Committee has been appointed by the Minister of Labour to be known as the "Port of London Casual Labour Committee," consisting of representatives of employers and workpeople in the London dock trade, under the chairmanship of Mr. Justice Roche, to enquire and report what action, if any, should be taken to regulate the work and reduce if necessary the number of casual labourers in the London Docks, and also, in view of demobilisation of the army and the cessation of munition work, to report on the best methods of preventing numbers of workmen, who are in difficulties as regards finding employment in their own trade, from resorting to the docks and wharfs and thus making the conditions of employment there more irregular than they were before the war.

Mr. George Langton, O.B.E., has been appointed vice-chairman, and Mr. P. G. Hurst, Ministry of Labour, Queen Anne's Chambers, S.W. 1, secretary of this committee.

Following upon the deputation from the National Federation of Discharged and Demobilised Sailors and Soldiers who waited upon him, Sir Thomas Munro met the representatives of the Federation again last week, and conveyed the following decisions on the points raised by them:—

1.—(*a*) With regard to Government factories, the disabled soldier employed in Government factories will (other things being equal) be discharged after the dilutee and the ex-service man, and will have last priority of discharge in his class of skill; (*b*) The Ministry of Labour will make an appeal to all factories, other than Government factories, asking them to adopt in regard to this matter the same procedure as the Government.

2. The Minister of Labour will obtain the necessary powers to take over from the Ministry of Pensions the responsibility for training ex-service men who require training, the Ministry of Pensions retaining, however, the powers necessary to enable them to deal with the training of men whilst undergoing medical treatment, *i.e.*, training in establishments of the institute type.

3. The Ministry of Labour has promised to schedule a list of occupations which are suitable for disabled men, and an appeal will be sent out by the Prime Minister urging employers to employ disabled men in such occupations when a post becomes vacant, and also to substitute disabled men for temporary war workers at present filling such posts. With regard to other occupations, the employers will be asked to make every effort to employ disabled men wherever possible.

4. The Minister of Pensions will obtain powers to proceed with the setting up of a certain number of factories solely for the employment of certain classes of disabled men who, on account of special disability may be found to be unable to engage in ordinary industrial occupations.

At a meeting of the Miners' Federation of Great Britain held at Southport last week, Mr. W. Adamson, M.P., moved the following resolution, which was carried:—

(*a*) That this conference demands that all the demobilised mine-workers shall be fully discharged from the Army and Navy, and, so soon as they are able and desire to resume work, shall be reinstated in the mines they left at the time of enlistment.

(*b*) Any such mine-worker not able to perform a normal day's work shall be paid the full wages appertaining to the grade to which he belonged had he not enlisted.

(*c*) Demobilised men who are disabled and unable to work in the mine shall be trained for suitable occupations and paid during the training an allowance equal to what they would have earned in or about the mine had they not been disabled, the allowance to continue after training until suitable employment is found, the cost of training and allowance to be at the expense of the State.

(*d*) Demobilised mine-workers and men who are displaced to make room for men returned from the Army or Navy shall be paid from State funds an out-of-work allowance equal to the wages they would have earned had they been employed in or about the mine.

(*e*) In no case shall wages or allowances interfere with the pensions to which discharged soldiers and sailors are or may be entitled.

(*f*) All matters coming within the above proposals shall be first dealt with by the joint committee of Mine-owners and Workmen, and, if necessary, submitted to the District Joint Committee.

(*g*) In order to make easier the realisation of these demands, we press the Government to amend the Miners' Eight Hour Act so that six hours shall be substituted for eight hours in the Act; also for this purpose, and in the interests of miners in particular and the community in general, we urge the Government to proceed at once to the nationalisation of all mines and minerals.

(*h*) That the Executive Committee interview the Prime Minister or some other Government representative on these proposals. Failing a satisfactory answer, a further conference be convened to determine the policy to be adopted to realise these demands.

At a later meeting of the Miners' Federation, the recommendation of the executive for a 30 per cent. advance on present wages was confirmed by a substantial majority. There voted—

For a 30 per cent. advance	....	512,000
Against	....	238,000

Three districts, South Wales, Lancashire, and Cheshire, and the Forest of Dean, voted against the recommendation on the ground of its inadequacy, they considering that the application should be for an advance of at least 50 per cent. on the present earnings.

In the course of a statement in regard to the claims for an advance in the miners' wages referred to above, Mr. Finlay A. Gibson, Secretary of the South Wales Coalowners, pointed out that in 1918 the total coal shipment was less than half the figure for 1913. The cost of production since the war began had more than doubled, whilst in the South Wales coalfield the smallest increase in the weekly minimum wages of any class of underground day-wage workman since 1914 had been 87 per cent., and the highest 200 per cent. The increase in the case of the class in which the largest number of day-wage workmen were employed was as much as 173 per cent. The lowest weekly wage paid in the South Wales coalfield to-day to a workman employed on day rates working full time was 64*s.* 9*d.*, and the highest 81*s.* 9*d.*, exclusive of overtime and other supplementary earnings, and also of the value to miners of the supply of house coal at the pre-war customary average price of about 6*s.* per ton. On an average, he added, these increases were far more than proportionate to the rise in the cost of living.

Labour absorbed anything from 65 per cent. to 75 per cent. of the price of coal; it was mainly owing to the wage increases that the pithead price of coal to home consumers, other than miners, had increased from 10*s.* 6*d.* to 13*s.* per ton above the price which ruled in 1914. America, he further said, was even now competing with British coal in the European and South American trades. The production in the United States was now also on an average 660 tons per person employed, as compared with 243 tons per person in the United Kingdom; further, that country was now in the possession of an enormous and increasing merchant fleet, which it was determined to employ in the world's carrying trade.

A deputation of the Executive Committee of the Associated Society of Locomotive Engineers and Firemen, was received last week by the President of the Board of Trade to discuss the national wages programme of the society. The proceedings were private.

At the close of the interview, Mr. J. Bromley, general secretary, said they were asking for £1 a day for drivers, 10*s.* for firemen, and 7*s.* for cleaners as standardised national wage rates. That was the programme put forward along with their claim for an eight-hour day and which, when the latter claim was conceded, was left over for future negotiation. They had called on the Board of Trade to discuss the preliminaries for setting up a committee of negotiation to settle the whole question. That might be their last visit to the Department, as it was probable that before long there would be a new Ministry set up to deal with the question of transport.

At the quarterly meeting of the Association of Chambers of Commerce which was held last week in London, Mr. E. Manville occupying the chair, four resolutions were on the agenda, tabled by Nottingham, Barnstaple, Walsall, and Leith with regard to the importance of effective Parliamentary legislation to secure cheap power supplies as one of the first essentials of reconstruction. At the suggestion of the chairman, the meeting decided to consider only the Leith resolution. This stated that, in the opinion of the Association, legislation should at the earliest moment be enacted to put into effect the recommendation of the Electric Power Supply Committee appointed by the President of the Board of Trade, after due consideration of the criticisms which have been put before the Government by duly qualified technical and commercial associations; that, with a view to economical production and distribution of power, a new central authority should be appointed to regulate the generation and

THE BRITISH CHANNEL TRAIN

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LTD., WALKER-ON-TYNE, AND THE FAI

(*For Description, see Page* 119.)

Fig. 14.
HARBOUR AND FORECASTLE DECK

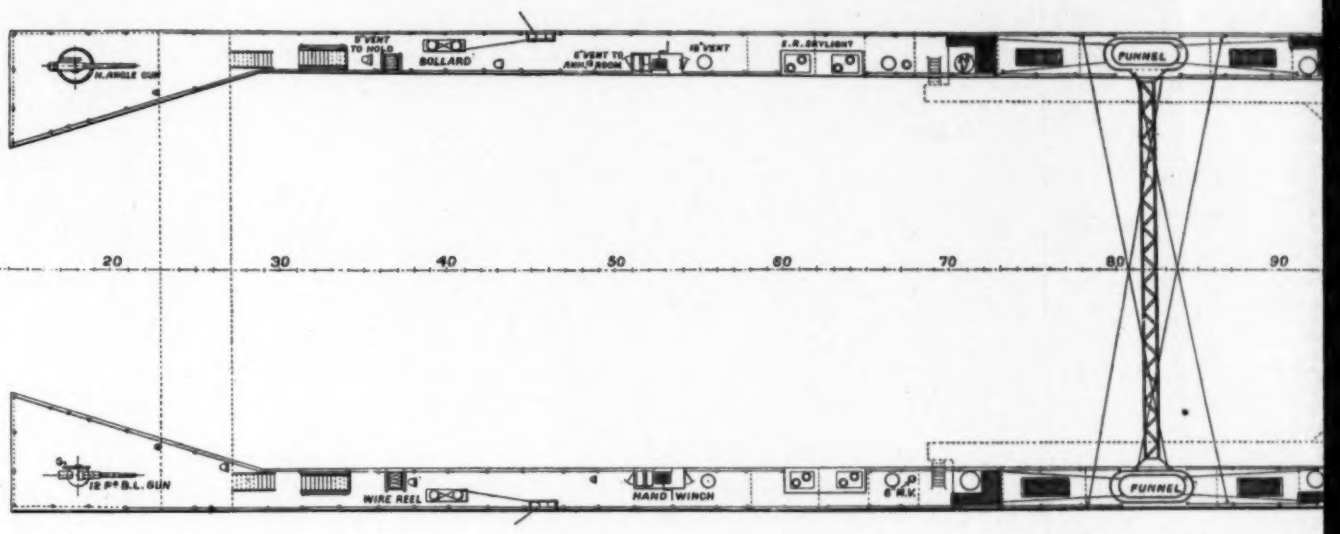


Fig. 15.
CAR DECK

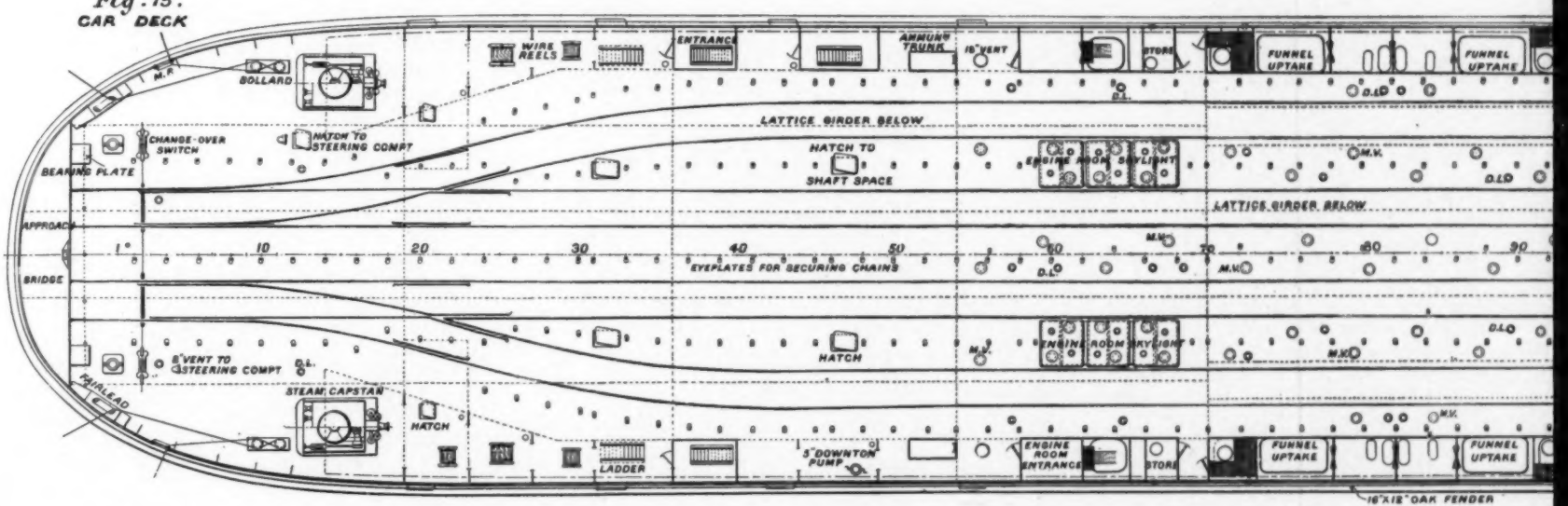
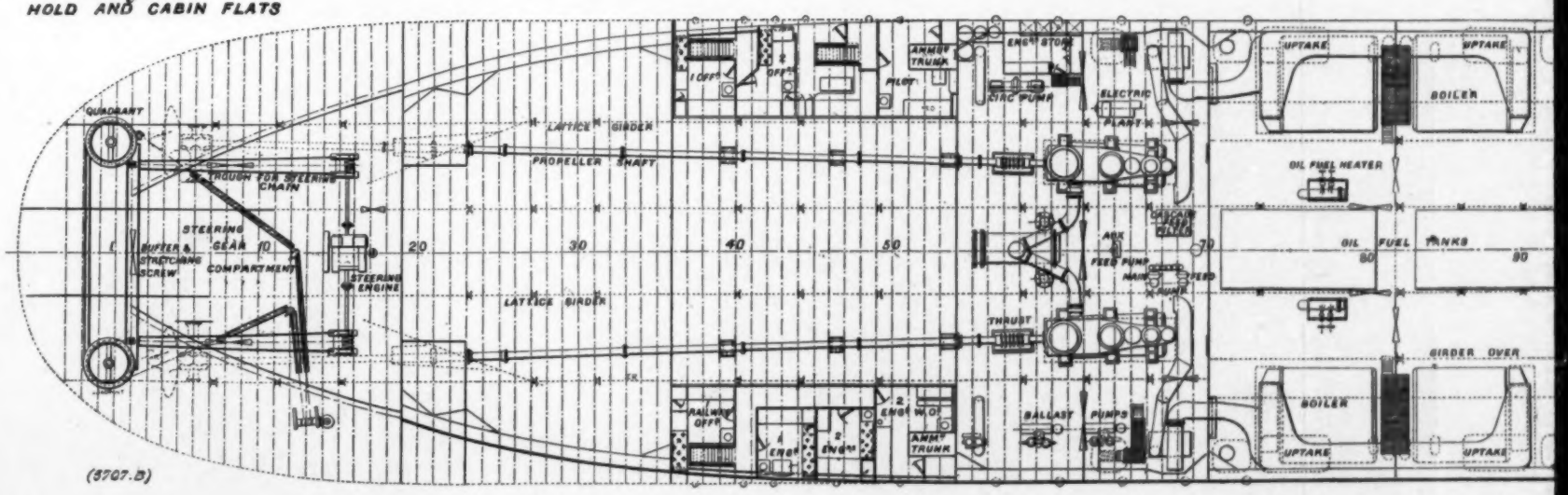


Fig. 16.
HOLD AND CABIN FLATS



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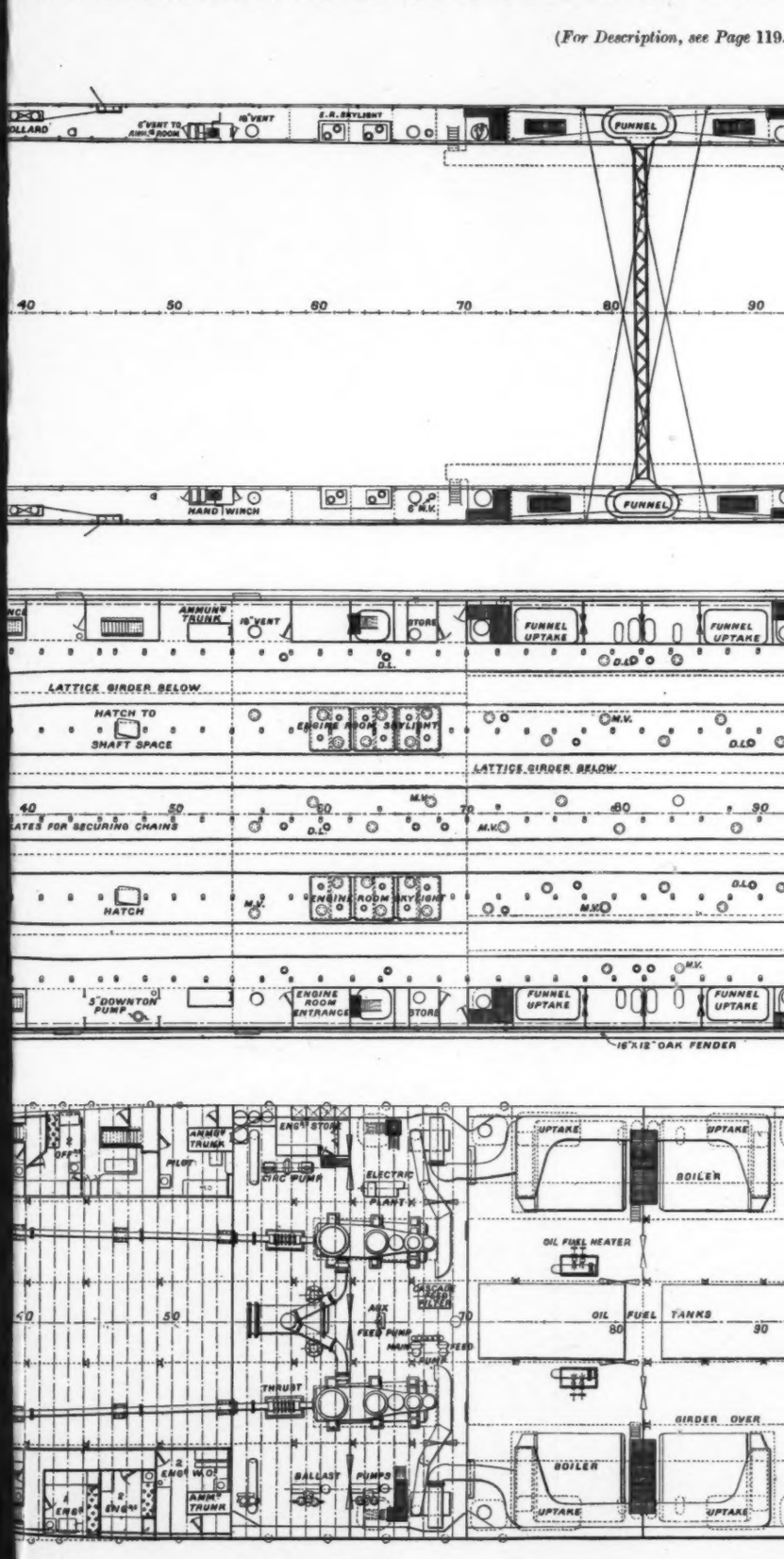

RAIN FERRY STEAMERS.

D THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LTD., GOVAN, GLASGOW.

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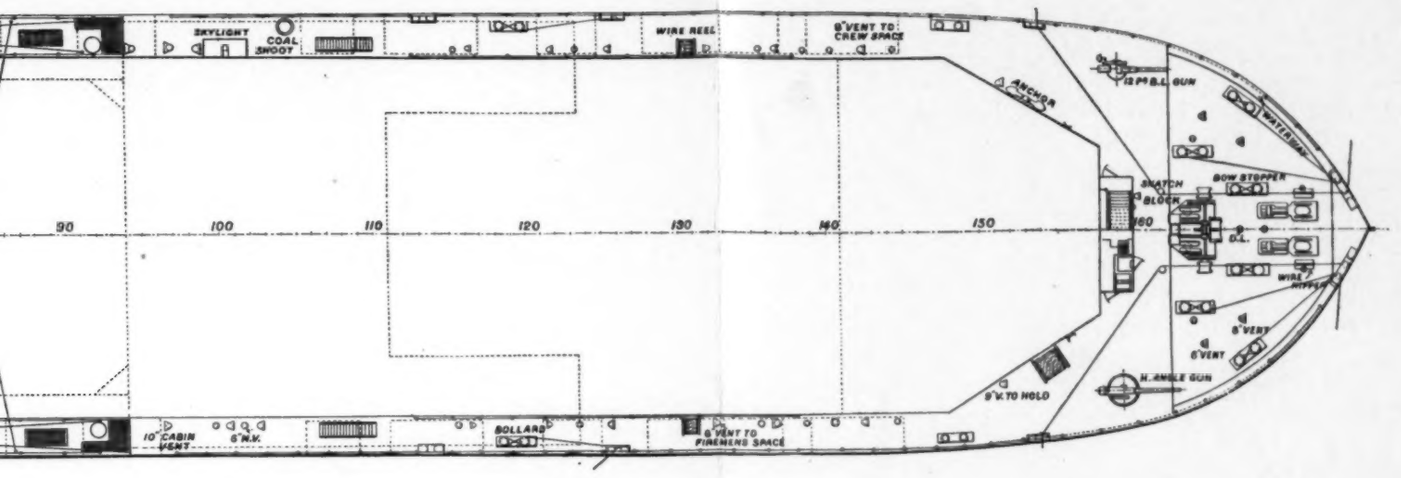

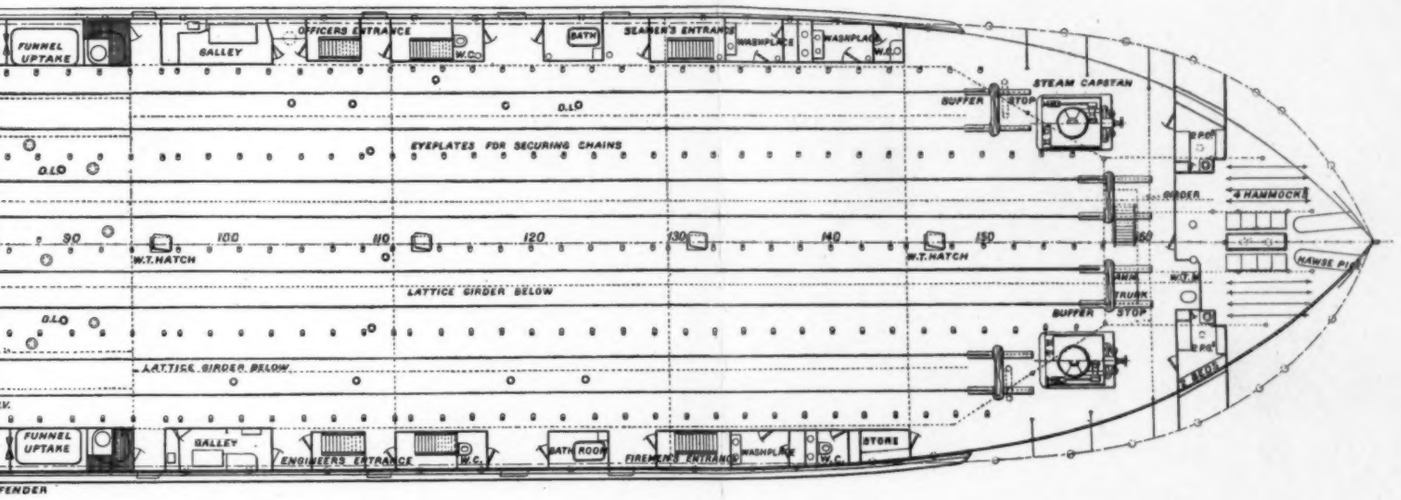

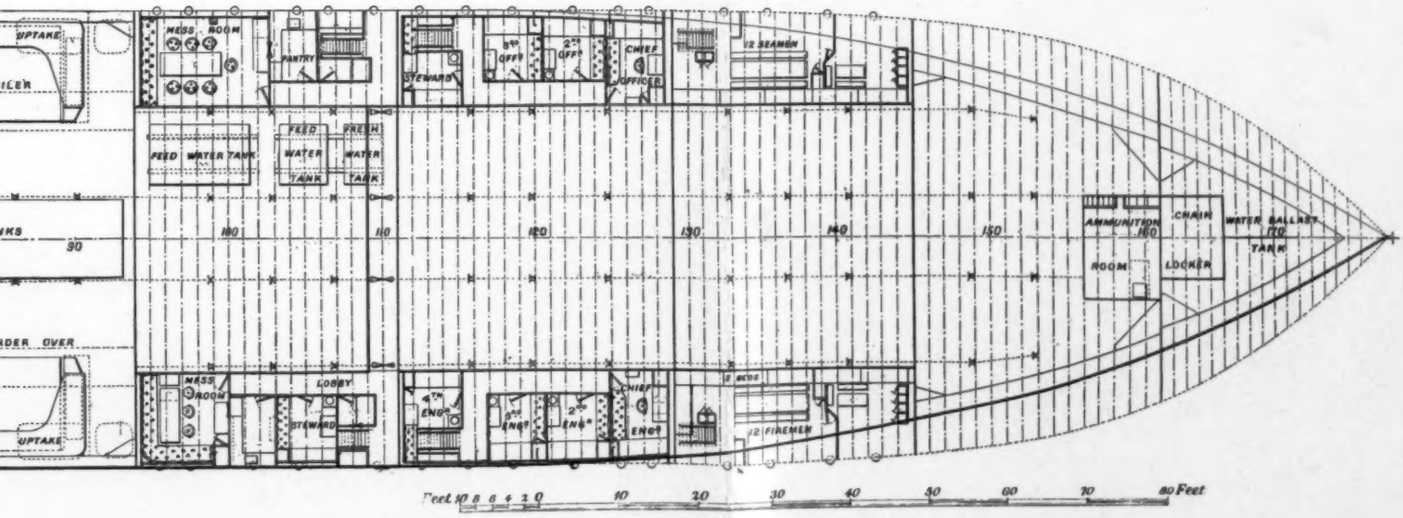

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(*For Description, see Page* 119.)

Fig. 4.

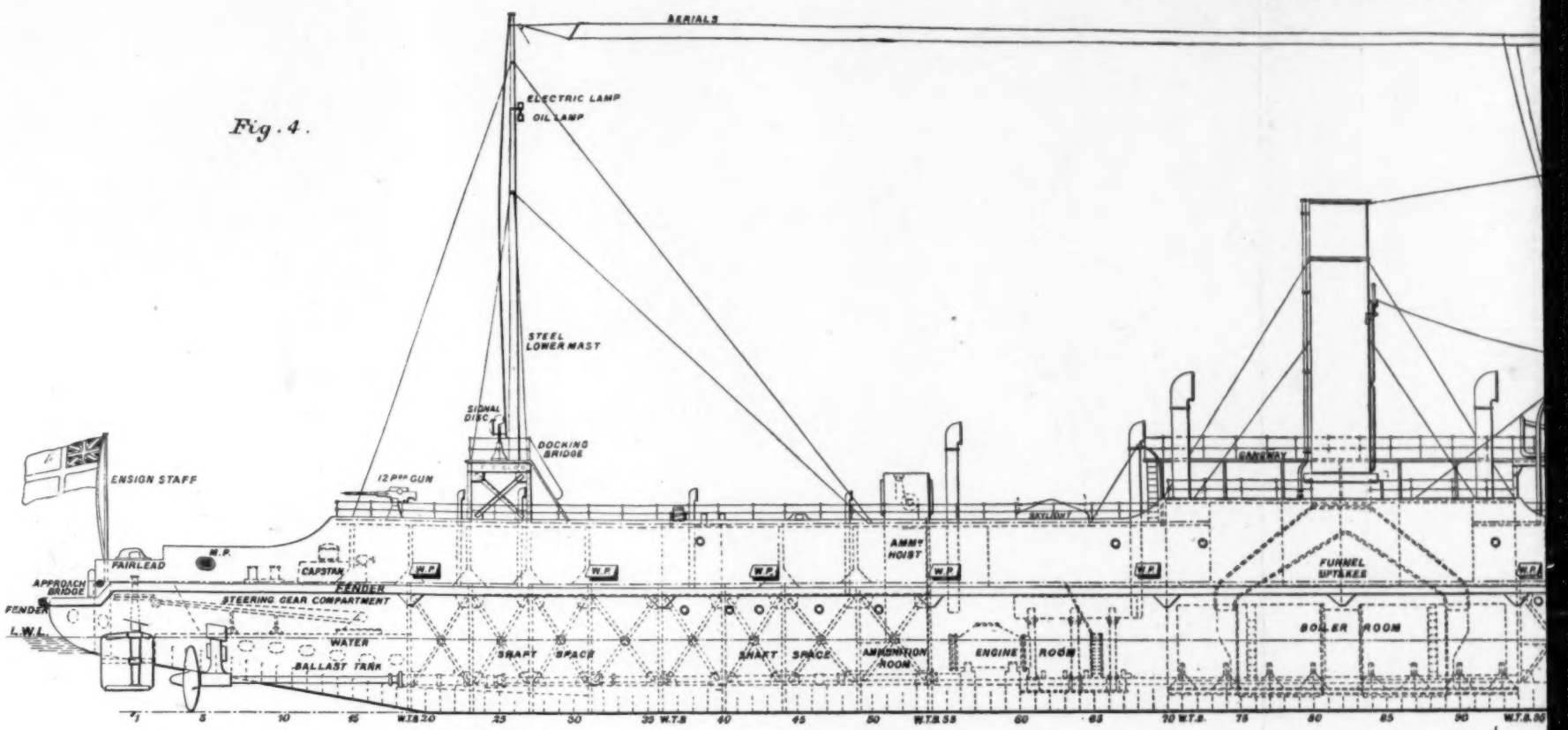


Fig. 5. DOCKING BRIDGE.

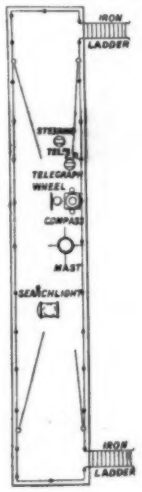


Fig. 6. FLYING BRIDGE.

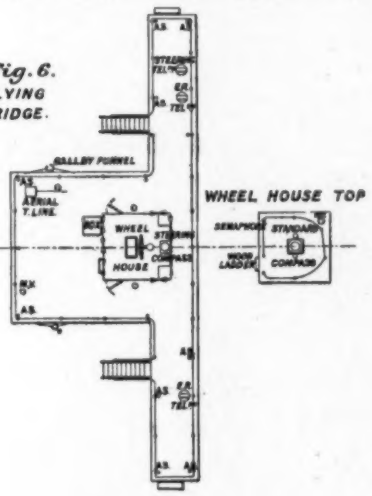
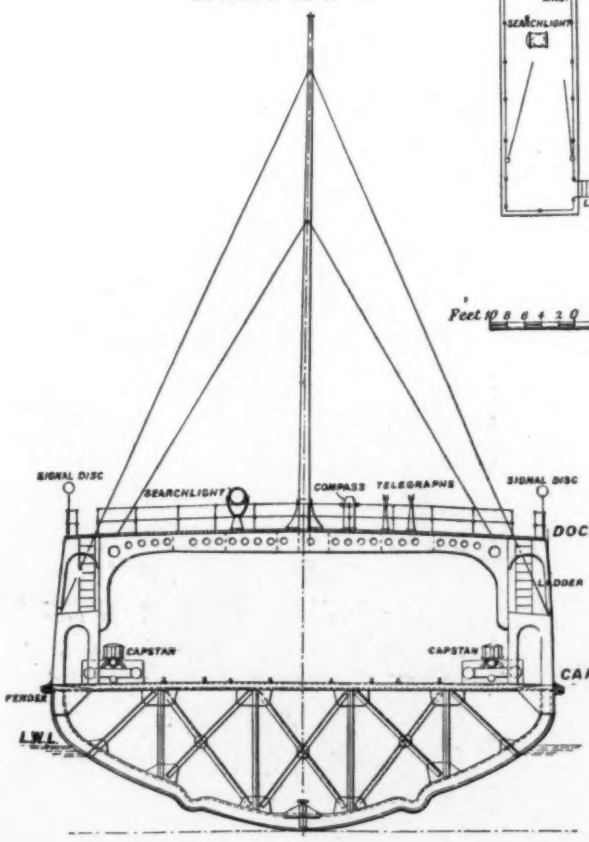


Fig. 7. BRIDGE DECK

Fig. 9. SECTION AT FRAME 30. LOOKING AFT.



Feet 10 8 6 4 2 0 10 20 30 40 50 60 70 80 Feet

Fig. 10. SECTION AT FRAME 60 LOOKING AFT.

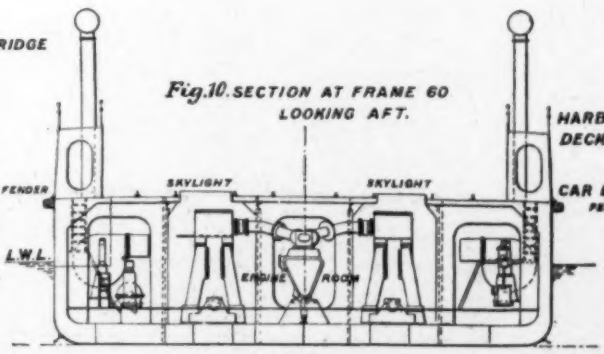
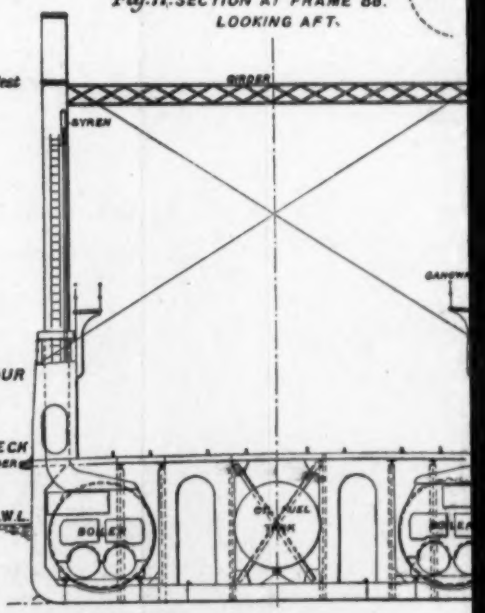


Fig. 11. SECTION AT FRAME 88. LOOKING AFT.



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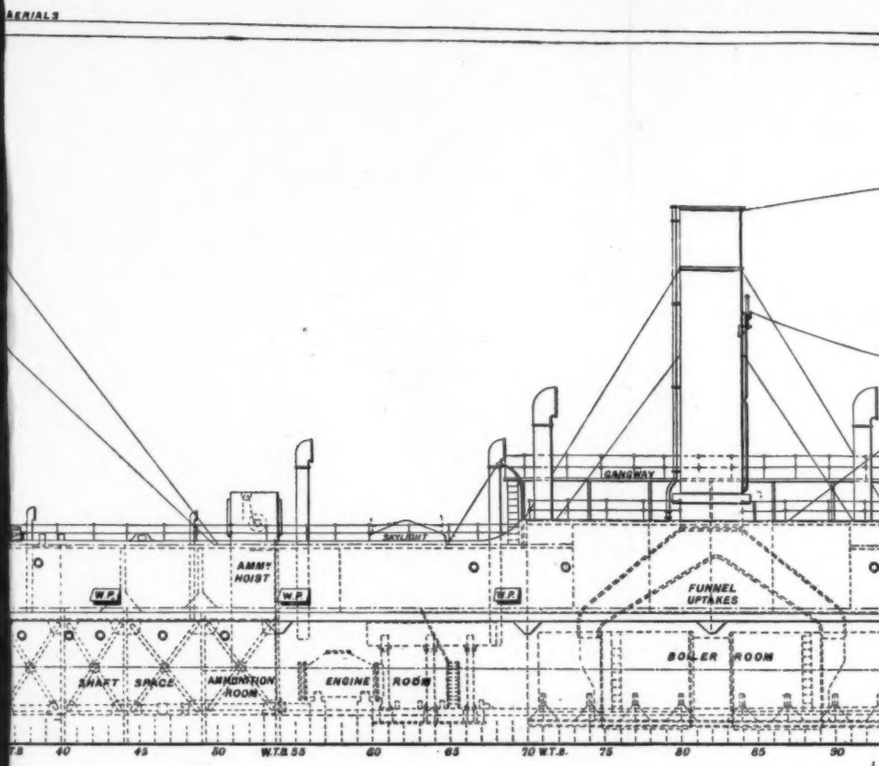

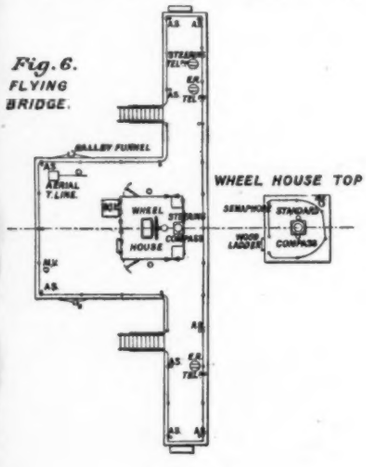

Fig. 6. FLYING BRIDGE.

Fig. 7. BRIDGE DECK

Fig. 11. SECTION AT FRAME 88. LOOKING AFT.

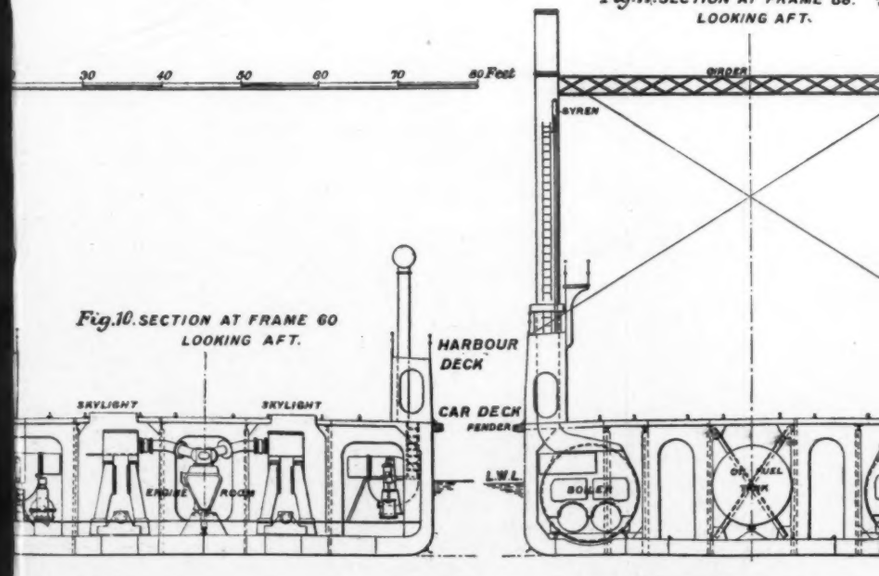

Fig. 10. SECTION AT FRAME 60 LOOKING AFT.

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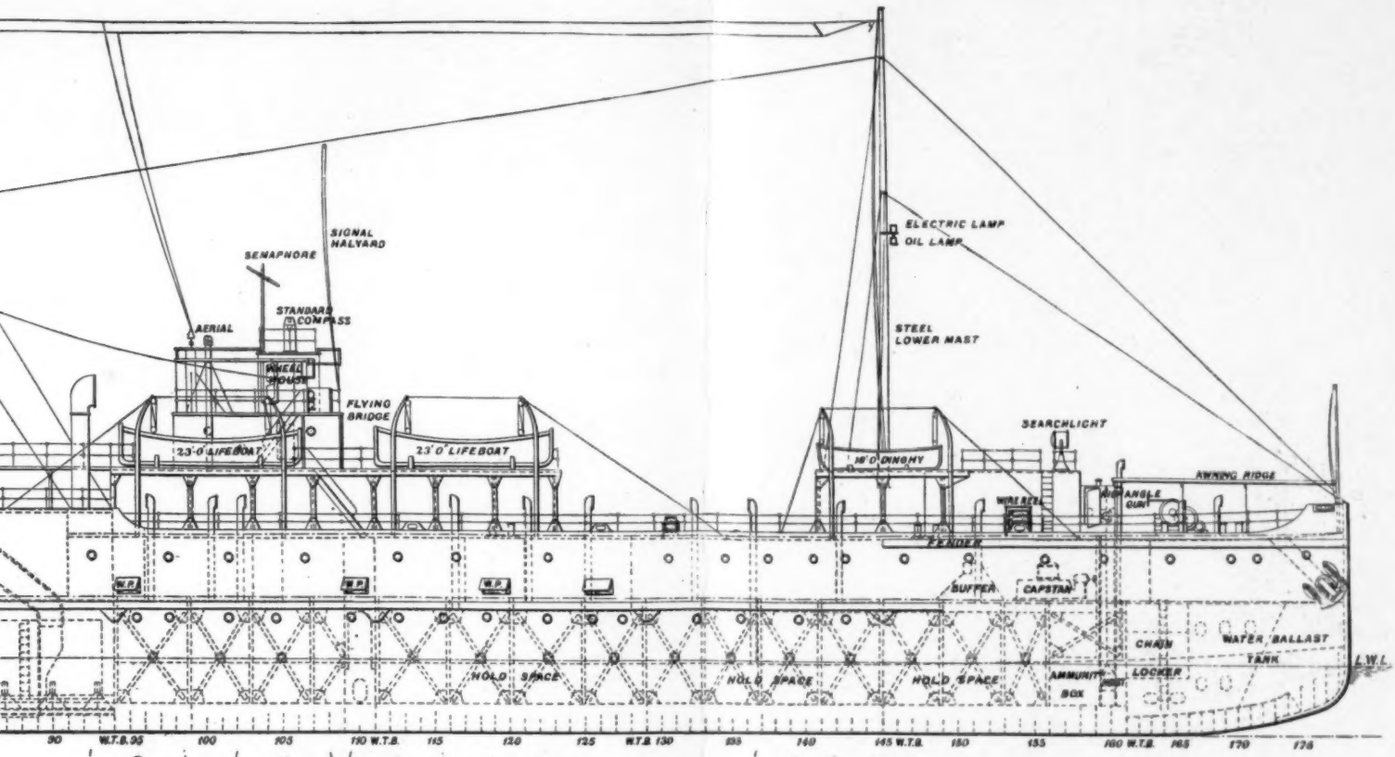
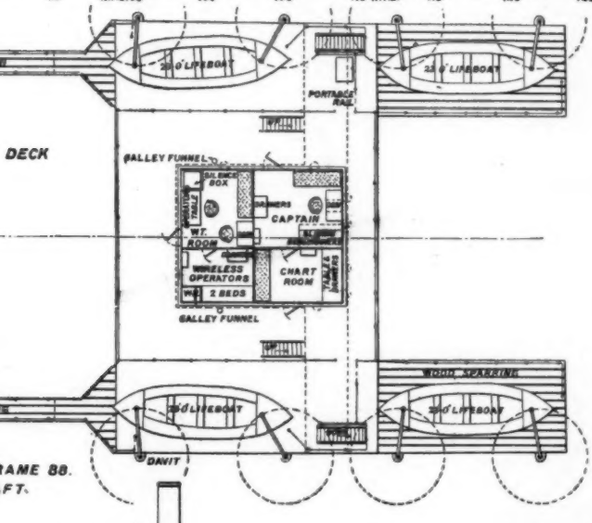




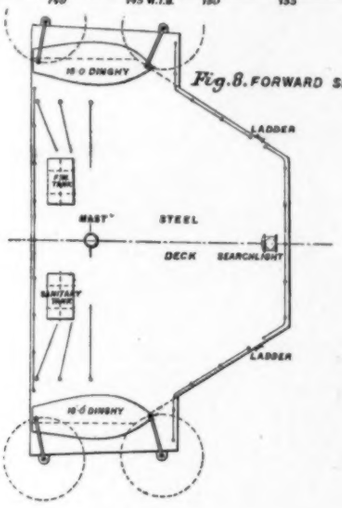


Fig.8. FORWARD SHELTER.

RAME 88.
FT.

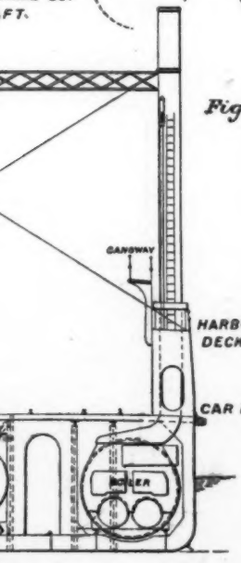


Fig.12. SECTION AT FRAME 103. LOOKING FORWARD.

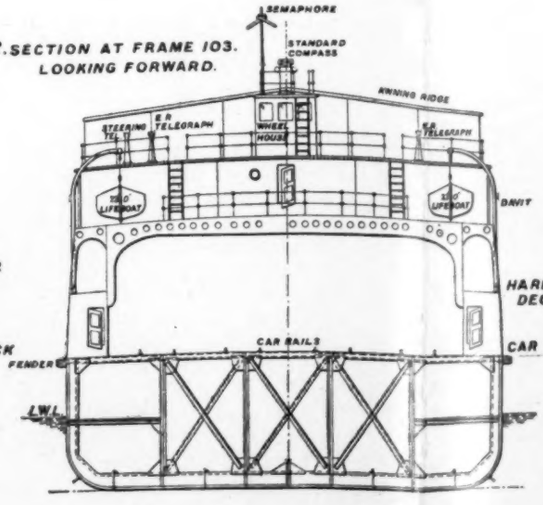
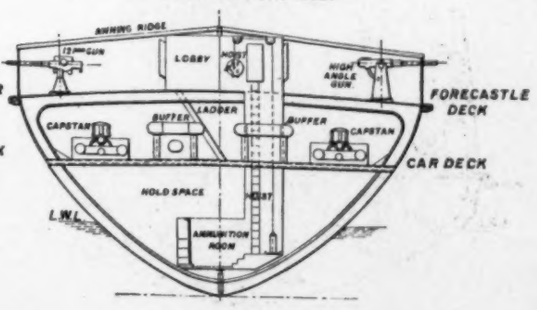


Fig.13. SECTION AT FRAME 157. LOOKING FORWARD.



distribution of electricity throughout Great Britain and Ireland.

Mr. Atkey, M.P. (Nottingham), who moved the resolution, said they wanted to give politicians a push. The best business brains should draft the Bill, and not leave it to the lawyers, who prepared Bills which could not be understood by an ordinary brain.

Mr. Russell (London), who seconded, complained that the report of the Board of Trade seemed to support the nationalisation of the electrical industry to a too great extent.

Sir John Maclaren (Leeds) said he could safely support the resolution. The recommendations of the Electric Power Committee were in the main admirable, but the Association, as a commercial body, were not, perhaps, qualified to deal with some of its technical aspects. From a technical point of view the report was excellent, but not from a commercial point of view. It would be necessary in some way to co-ordinate the two views. In Yorkshire there were very large electrical undertakings which would be vitally affected, and steps should be taken to conserve the interests of local companies where the services were good.

Mr. Hobson (Sheffield) said that if large generating stations were to be put in the best places, from a national and natural point of view, we must have legislation far more drastic than had ever been thought of before in regard to landowners' rights to way-leaves. Many complex subjects were being raised by the legislation promised.

Mr. Webb (Leicester) stated that during the war Sheffield had increased its electrical industry ten times.

Mr. Shaw (Newcastle) opposed any nationalisation of the electric supply. In Newcastle they had considered what could be done to absorb the very large number of people who had in the last four years been employed on munition products. They had considered the establishment of 12 new industries on Tyneside, and of these nine were dependent upon a cheap supply of power. The resolution was adopted.

In a letter to *The Times* of last Tuesday, dealing with the unrest in shipyards, a correspondent states that a new construction plating squad consists of a number of platers and a larger number of helpers. The platers contract through their leading hand with the management to undertake a particular job at a certain piece price. Then, except in the case of "Royals," that is to say, premier squads with permanent *personnel*, the leading plater usually engages his helpers in the "helpers' market." The helpers are paid, either by the platers or through the office, an hourly or weekly wage, which comes in any event out of the price of the job. The Wear affords an exception. There the helpers receive a fixed proportion of the platers' earnings.

The faster the job is pushed, and the greater the output, the larger are the platers' earnings. Yet the helper, whose exertions are as essential to production as the plater's, is paid a fixed time rate, no matter how great may be the output to which he has contributed. The platers who pay the helpers disclaim any inequity, and say that the helpers' standing wage is fixed sufficiently high to compensate for this very contingency. That, however, may be dismissed as a convenient fiction. The fact is that the platers in special cases, to secure expedition and larger earnings, pay the helpers a "back-handed bonus" over and above their standing wage.

During the war the helpers proposed that they should be paid on the same basis as the platers—namely, in proportion to the output. They had equity on their side. It was surely unreasonable to expect them to put forth special exertion only to see the extra earnings resulting from their extra effort going into the pockets of the platers. But the platers' organisation frowned on the proposal, and was not prepared to pay anything further to the helpers out of the piece price unless the employers were prepared to make a percentage addition to the price for that express purpose. The employers took up the opposite position. While not averse to the helpers being paid according to output, the whole extra payment, in their view, should come from the platers. Both employers and platers overlooked the fact that increased production was of material value to both of them. So the old system still remains to impede production.

The whole purpose of the 47-hour week is, by reduced hours, to conserve the health of the workers, and by maintenance and if possible increase of production, to avoid reduction or even to secure an advance of wages. A reduction of hours where the helper is paid an hourly rate is a clear reduction of his weekly wage. If paid by the week, and his weekly wage is allowed to stand unaltered, his earnings will naturally remain the same. But in the reduced working time, for which the helper would be paid a wage less than or equal to his old wage, the plater, to maintain his old earnings, will, and in the interests of industry ought to be encouraged to, work at an increased rate of output. This he cannot do without the helper's co-operation, and the latter he will not get unless and until the helper is assured of a definite financial interest in the increased effort demanded of him. One thing is certain, mere maintenance of the helper's old wage, or a flat addition thereto irrespective of output, however serviceable as a temporary palliative, is no permanent remedy—but a certain source of future trouble.

ELECTRIC POWER SUPPLY.

WE have been requested by the Institution of Electrical Engineers to give publicity to the subjoined important letter which has been addressed to the President of the Board of Trade :—

Temporary Offices,
1, Albemarle-street, London, W. 1,
January 1, 1919.

The Right Hon. Sir Albert H. Stanley, P.C., M.P.,
President of the Board of Trade,
7, Whitehall Gardens, S.W. 1.

SIR,—

ELECTRIC POWER SUPPLY.

1. On June 27, 1918, the Council of the Institution of Electrical Engineers took into consideration the reports of the committees appointed by the Board of Trade on Electric Power Supply (Cd. 9062) and Electrical Trades after the War (Cd. 9072).

2. These official reports embody recommendations leading to drastic revisions of the conditions under which the electrical supply industry had been carried on in Great Britain. Recognising that the future course of development in electricity supply for industrial and domestic purposes, in electric traction, in electrical manufacturing, and in many other branches of electrical business depended on the character of the legislation based upon these reports, the council were convinced that the Institution of Electrical Engineers, as the body including and representing those engaged in all sections of the electrical industry, should endeavour to obtain and to collate the opinions of these sections on the fundamental issues involved.

In view of the vital importance of a cheap and abundant supply of electricity to the engineering and other industries, the council decided to form a special committee and to include therein representatives of the most important consumers of electric power.

3. Each of the following bodies was invited to nominate two representatives, who, with the president and four vice-presidents of the Institution of Electrical Engineers acting *ex-officio*, would constitute the committee :—

The British Electrical and Allied Manufacturers' Association.
The Association of Consulting Engineers.
The Federation of British Industries.
The Cable Makers' Association.
The Incorporated Association of Electric Power Companies.
The Provincial Electric Supply Committee of the United Kingdom.
The Tramways and Light Railways Association.
The British Electrical Federation, Limited.
Edmundsons' Electricity Corporation, Limited.
The Iron and Steel Institute.
The Conference of Directors of the London Electric Supply Companies.
The Electrical Contractors' Association.
The Incorporated Municipal Electrical Association.
The Association of Municipal Corporations.

4. At a preliminary meeting of the committee, held on July 29, 1918, it was agreed that each association represented should give separate and independent consideration to the reports of the two Board of Trade committees, and should draw up their recommendations as to the main lines which future legislation should follow. The Incorporated Municipal Electrical Association and the Association of Municipal Corporations had, however, decided to submit separate reports to the Board of Trade, and were not represented on the committee.

5. The reports of the remaining associations were duly prepared and laid before the committee, after having been adopted in most cases by the respective councils of the associations. They accordingly embody the considered opinions of the accredited representatives of several large groups of electric supply undertakings, the great majority of electrical manufacturers, consulting engineers, and the most important users of electric power for industrial purposes in Great Britain.

6. Some of the reports were less detailed than others, and it is therefore not possible to present a combined opinion upon all the matters dealt with by the two committees of the Board of Trade. On no point of primary importance, however, is any material difference of opinion displayed. Substantially on the main issues relating to present electrical legislation the various associations showed an impressive unanimity.

7. The following views and recommendations in regard to electric power supply more particularly are, therefore, presented as expressing the united convictions of the committee, and through them of the many sections of industry which they represent :—

(a) The restrictive conditions embodied in the Electric Lighting Acts, the Tramways Act, the Light Railways Act, and the various Acts relating to electric power supply, have had a most detrimental effect on electrical progress in Great Britain. This legislation has led to the multiplication of small, arbitrary, and uneconomical areas of electricity supply and systems of electric traction; it has discouraged the investment of capital in electrical undertakings by imposing limited tenure with unattractive terms of expropriation and various other onerous conditions; it has placed obstacles in the way of grouping undertakings into comprehensive systems of supply and transport; it has, generally, prevented British electrical engineers and manufacturers from realising in their own country the highest achievements of which their technical skill and productive capacity were capable, and it has in consequence put them under a serious handicap in the competition for export business against countries in which the conditions have been more favourable for successful commercial demonstration.

(b) The evil effect of past legislation, emphasised so strongly by both the official reports, necessitates drastic reform of the enactments referred to, both in the spirit and the letter, if the industry is to fulfil its function of providing cheap and abundant electricity for industrial, agricultural and domestic purposes, and for the development of electric traction on railways, light railways, and roads.

(c) In addition to releasing electrical enterprises from the existing disabilities the chief necessities of the situation are (1) the treatment of the problem of electrical generation and distribution on broad lines, and (2) the provision of simple forms of procedure in obtaining power for electrical utilities of all kinds.

(d) In order to secure these and other essentials of ordered progress, the proposed appointment of a Board of Electricity Commissioners is welcomed subject to the provisions expressed below.

(e) The committee are strongly convinced that, owing to the complexity of the technical, administrative and financial problems involved in a comprehensive scheme of electric supply reform, it will be found altogether impracticable to deal directly with the task of reconstruction by means of general legislation covering all the points at issue. They accordingly urge that immediate action should be confined to the creation of the Board of Electricity Commissioners, who should have powers and functions as outlined in the following paragraphs. There should be a gradual development in the establishing of the administrative machinery as the necessity is felt, otherwise the industry may be hampered in the future by excessive organisation, to the same extent as it has been in the past by the conditions which have been referred to.

(f) This board should be a tribunal of skilled men, free from political influence, charged generally with the duties of (1) examining all proposals for the extension and consolidation of existing electrical enterprises; (2) recommending to the Board of Trade and to Parliament, for authorisation, schemes which are on the soundest financial and engineering lines; and (3) advising the Government on legislative matters for the encouragement of the electrical industry.

(g) The functions of the board should be exclusively judicial and advisory. Strenuous objection is urged against the granting to the board of administrative powers over electrical undertakings and also of authority to appoint District Boards in the event of such bodies being constituted. In this respect the powers of the Commissioners should be limited to examining schemes brought before them for dealing with the various districts.

(h) The preparation of such schemes, whether company, municipal, or joint, should be left as a matter of free and natural development to the initiative of undertakers, who would formulate such schemes (it may be rival schemes) and put them forward for the consideration of the Commissioners, who would report to Parliament upon any Bills intended to carry them into effect. Opponents would be entitled to be heard against such Bills in the usual way.

(i) The board may be empowered to deal with the Electrical Rules and Regulations administered by the Board of Trade and the Home Office, and it may also act as arbitrator and as a Court of Record for the electrical industry.

(j) The Railway and Canal Commission is suggested as a general model for the constitution and powers of the board.

(k) The number of Commissioners on the board should be five, and in all cases the appointments should be permanent, or for long periods, and should be on such conditions as will attract men of the highest ability, knowledge, and independence. One member should be skilled in legal affairs and in sifting evidence, one in finance, one in the problems of electrical manufacture, and the others with experience in engineering and the management of electrical undertakings.

(l) While in the main the work of the board will consist of formulating the principles of procedure in the course of electrical progress, and of recommending the legislative amendments and the specific schemes which are in agreement with these principles, it may be necessary in some cases for the board to propose the enforcement, by Parliamentary authority, of arrangements for interconnection or amalgamation of supply undertakings.

8. Recommendations have been made by various associations represented on the committee regarding specific matters dealt with in the reports of the two Board of Trade Committees, but it is felt that these problems will receive a satisfactory solution as a result of the formation of an independent authoritative Board of Electricity Commissioners, which is the crucial matter at this stage.

I am directed respectfully to urge on behalf of the committee that legislation adverse to the views of the large proportion of the industry and of the consumers which the committee represents may not be introduced without their being accorded an opportunity of discussing the matter with you.

I have the honour to be, Sir, your obedient Servant,
(Signed) P. F. ROWELL, Secretary, I.E.E.,
On behalf of the Committee.

THE UTILISATION OF SHIPYARD REFUSE.

On this and the opposite page, we illustrate a destructor recently installed at the Birkenhead works of Messrs. Cammell, Laird and Co., Limited, by Messrs. Meldrums, Limited, of Timperley, near Manchester. The large amount of combustible refuse which was unavoidably produced at the Birkenhead yard had previously been treated as a mere nuisance and got rid of by dumping. It is now burnt in the destructor, and the resulting products of combustion being led into the furnaces of a marine-type boiler, yield a supply of over 10,000 lb. of steam per hour at a pressure of 85 lb. per square inch. The general arrangement of the plant is clearly shown in Figs. 1 to 3, whilst some details are illustrated to a larger scale in Figs. 4 to 6, page 111.

The destructor is one of the makers' standard three-grate type, arranged for both top and front feed. The top feeding doors are utilised for the feeding in of such light stuff as shavings, sawdust and waste; whilst heavier pieces, such as refuse timber, are fed in through the front doors. The grates have each an area of 25 sq. ft., and the interior of the destructor is lined with best quality firebrick. A Keith-Blackman fan, driven by a Westinghouse electric motor, supplies the forced draught required. The products of combustion are led through three steel flues lined with firebrick, to the furnaces of the boiler, as is best seen in Figs. 4 to 6, page 111. This boiler is 15 ft. in diameter by 11 ft. long, and its three furnaces are 3 ft. 10 in. in diameter. The destructor was guaranteed to burn 40 tons of refuse per 24 hours, but as the results of the reception trial detailed below show, a much higher rate of combustion was actually attained. The trial figures are as follows:—

Test on "Meldrum" Destructor and Waste Heat Boiler.

Date of test.—May 23, 1918.

Duration.—5¼ hours, 10.10 a.m. to 3.55 p.m.

Fuel consumed—	T.	c.	q.	lb.
Shavings, &c., from joiners' shop and saw mills	3	6	0	0
Ashes, tar, carbon, &c., from gas plant	6	10	0	0
Refuse from shops and yard	3	2	0	0
Scrap timber, &c.	0	5	0	0
Total = 13 tons 3 cwt. =				29,456 lb.

Fuel per hour	5,123 lb.
Total water evaporated by boiler	6,800 gallons.
Total water evaporated per hour	1,182 gallons.
Total water evaporated per pound of fuel	2·3 lb.
Feed temperature entering boiler	87 deg. F.
Average steam pressure ...	85 lb. sq. in. gauge.
Weight of clinker	3 tons 10 cwt. = 7,480 lb.
Weight of clinker, per cent. of fuel fired	26·6 per cent.

Analysis, waste gases leaving boiler—

	Per Cent.
CO_2	16·4
CO	0·4
O	0·2
N (difference)	83·0

Equivalent evaporation F. and A., 212 deg. F. = 2·6 lb. per pound of fuel.

TWO NEW ELEMENTS, NEOMOLYBDENUM AND NEOTUNGSTEN ?—In the periodic table of the chemical elements, chromium, molybdenum and tungsten form a sub-group with the atomic weights of 52, 96, 184, and there should be a parallel group of which only the first member, manganese, atomic weight 55, is known; the other two hypothetical elements, the ekamanganese and dvimanganese of some investigators, which should have the atomic weights 99 and 187, are missing. The former element was supposed to have been discovered by Ogawa, in Japan, in 1908, who named it nipponium; but there has been no confirmation of this research. Last year M. Gerber published in the *Moniteur Scientifique* (April, June, August, October, 1917) a detailed account of a long-continued search for these elements which he has been carrying out in the laboratory of the firm of Michelin et Cie., of Clermont-Ferrand. The account bears the stamp of a conscientious, very painstaking research, and we regret to read that Gerber had to postpone his work owing to illness. He had already secured much evidence of the existence of neomolybdenum and neotungsten, however, performing many analyses which would assign to them nearly the predicted atomic weights of 99 and 187. In his search he first used large quantities of manganese salts and of ferro-manganese; but he did not find evidence of any new element in them. He then turned to ores and salts of molybdenum and tungsten and, hunting up the literature, he found that the elementary character of these two metals had repeatedly been questioned. As regards tungsten, there were in particular the investigations of A. Laurent, of 1844 (on a green tungstic acid, the ordinary acid is yellow) and of F. A. Bernoulli, of 1880, which he confirms, whilst he does not agree with Ogawa. Spectroscopically, the two new elements appeared indistinguishable from molybdenum and from tungsten.

REFUSE DESTRUCTORS AT TRANMERE SHIPYARD.

CONSTRUCTED BY MESSRS. MELDRUMS, LIMITED, ENGINEERS, MANCHESTER.

Fig. 1. SIDE ELEVATION.

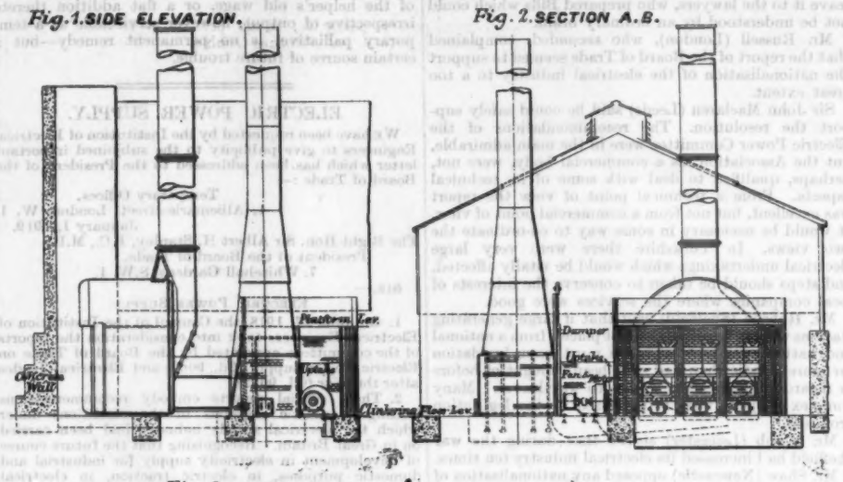
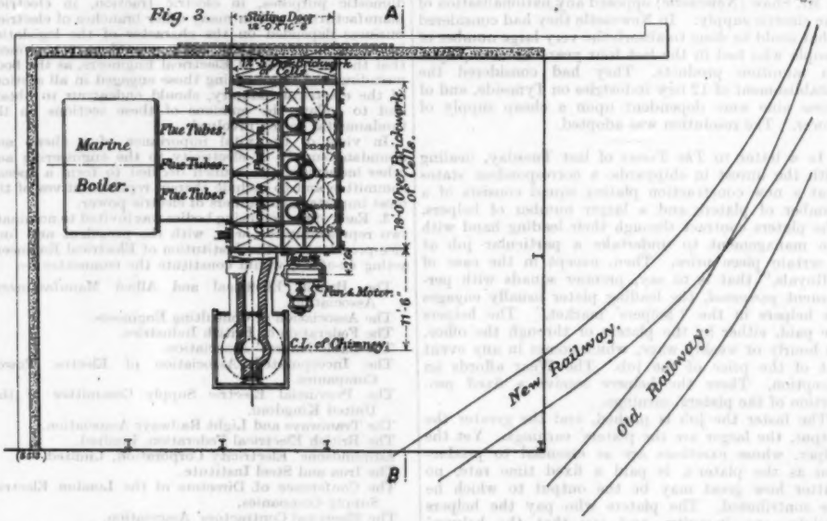


Fig. 2. SECTION A.B.

Fig. 3.



THE LARGEST PLATE ROLLING MILL IN THE WORLD.

THERE is brisk and friendly rivalry in the United States between various steel manufacturers to possess the largest and most efficient plant. In connection with plate rolling mills the Lukens Steel Company, of Coatesville, Pennsylvania, has always endeavoured to maintain the lead, and although it has several times been temporarily passed by its competitors, it has always forged ahead to the front in a short time. In 1890 it began operation with a 120-in. sheared plate mill which was then the largest of its kind. After a time another firm laid down a larger mill, but the Lukens mill was then rebuilt to 134 in., and regained its position of superiority. A 136-in. mill was then installed by another company and remained the largest until, in 1903, the Lukens Company put into service their present three high 140-in. unit. The next advance comprised two 152-in. 3-high mills, which carried the palm for size until the Lukens Company put down the 204-in. mill which we illustrate on page 114. This is not only the largest mill in the United States, but there is no larger in the world. It is evidence of the great advance which has been made since the Lukens Company rolled the first boiler plate in America about 1820.

The mill illustrated is a 4-high reversing type mill, 204-in. (17 ft.) wide on the rolls. It is capable of rolling plates up to 192 in. (16 ft.) in width, and circular plates a few inches wider. It will exceed by a wide margin the 178-in. mill of the Witkowitz Works in Austria, and the 168-in. mills which are the present limit of the 2-high plate stands in the United Kingdom.

The decision of the Lukens Steel Company to build the largest plate mill in the United States came about in an interesting way. Because of the growing demands from ship and car builders, railroads and other large plate users for constantly greater widths, the Lukens Company took into consideration the building of a 180-in. 3-high mill after the accepted American standard.

This mill as first planned also would have been larger than any to be found to-day either in the United States or in Europe. When it came to obtaining the chilled rolls of the size and weight desired, however, there was no manufacturer to be found in the country who could be persuaded to undertake the contract. The 50-in. diameter rolls required for a mill of the 3-high type that had been settled upon, were far greater than anything the roll-makers had ever attempted, and difficulties of manufacture were presented which forbade them bidding for this business. The result was that it was impossible to obtain rolls of the size and weight desired in the United States. It was then that Mr. Charles L. Huston, vice-president and mechanical engineer of the Lukens Company, proposed the adoption of the 4-high reversing type of mill, which he had previously been studying to meet such a situation, in order to maintain the fine chilled roll finish upon the plates and thereby avoid the difficulties of roll manufacture that had been encountered, and admit of using a still larger size than 180 in. The detail designing of the mill has been carried out by the joint collaboration of the engineering staff of United Engineering and Foundry Company and Mr. Paul C. Haldeman, master mechanic of the Lukens Steel Company.

The new mill is built on the principle of the 2-high reversing plate stand commonly used in the British Isles, with a modification, viz., that the two finishing rolls are backed by two large supporting rolls. The purpose of these latter rolls is to stiffen the mill, and to give it the added strength necessary to prevent springing of the operating rolls when rolling wide, thin plates, thus insuring uniform thickness in the finished product. This arrangement also enables the use of operating

REFUSE DESTRUCTORS AT TRANMERE SHIPYARD, BIRKENHEAD.

CONSTRUCTED BY MESSRS. MELDRUMS, LIMITED, ENGINEERS, MANCHESTER.

(For Description, see opposite Page.)

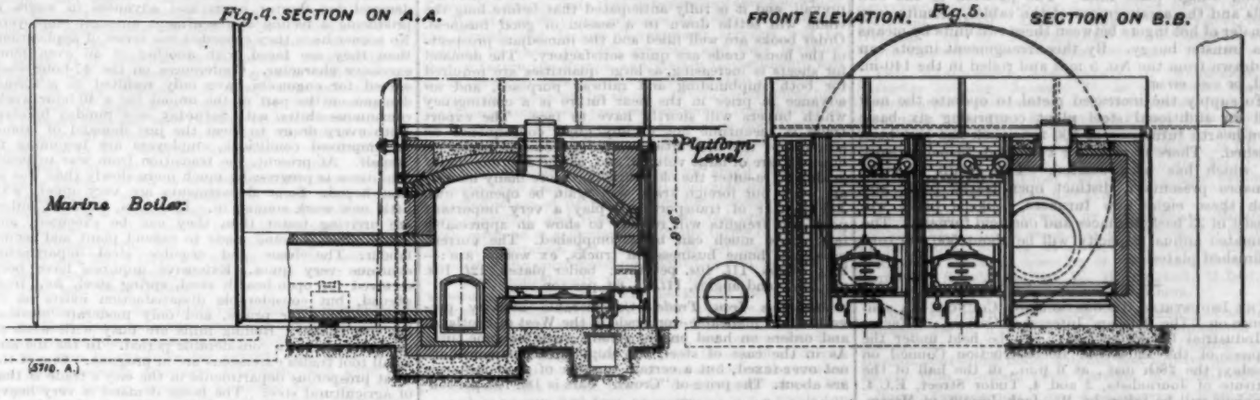
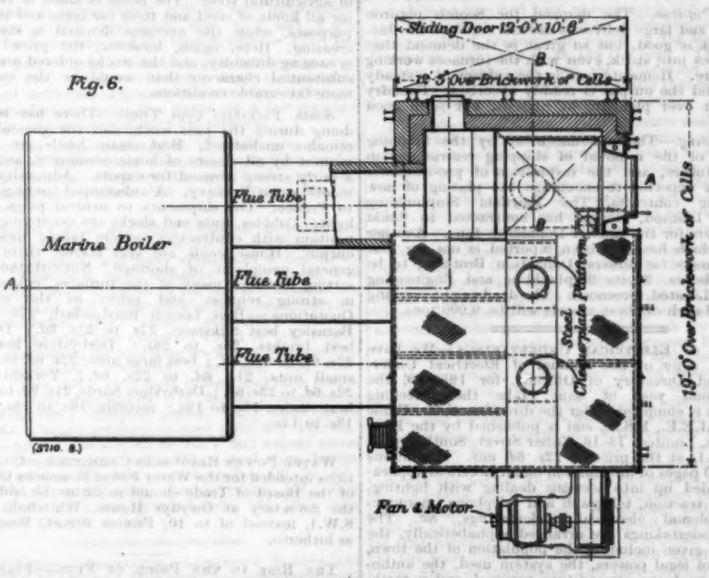


Fig.6.



rolls of smaller diameter, and thereby overcomes the difficulties of obtaining chilled rolls of the size which would be required in a 3-high mill of this extreme width. There are two 34-in. diameter by 204 in. working face operating rolls of chilled iron with 27-in. necks, weighing about 30 tons each; and two 50-in. diameter backing rolls of cast-steel with 36-in. necks weighing about 60 tons each.

The housings of the mill are of steel, and are built up in four parts, consisting of two side pieces, a top bridge piece containing the screw box, and a bottom bridge piece in which is located the seat for the bottom rolls. This novel method of construction is necessitated by the unusual size of the housings which preclude their being cast in one piece, since their machining and transportation in such form would be impossible. Each housing thus built up weighs over 400,000lb. The mill stands about 40 ft. from the top of the screw cover to the bottom of the shoes, and its overall dimensions are slightly over 42 ft. The housing shoes are spread 16 ft. 9 in. between centres, and are of special design with extra large bearing surfaces.

The foundation of the mill is of concrete built on solid rock. It is of strong, simple design, which is made possible by the cylinder arrangement. The two top roll supporting cylinders are carried on the top spreader between the housings, and are so arranged that they can be used as operating cylinders for changing rolls. The screw-down rig is of the well-known worm and worm wheel design, and is driven by two 150 h.p. motors, one on each housing. These motors act as a roll release in case of a stall.

The mill pinions are of cast-steel, and have double helical cut teeth, 42-in. pitch diameter by 60 in. face. These pinions are connected to the working rolls by spindles 20 ft. long. The bottom spindle is of the usual design, while the top or vibrating spindle has special universal couplings. To insure the driving of the bottom backing-up roll, it was deemed necessary by Mr. C. L. Huston that this should have some suitable power connection between the pinions and the mill, as it was feared there would not be sufficient friction between the bottom working roll and the backing-up roll to drive the latter at all times. This power connection has been accomplished by means of a friction clutch, which gives a sufficient drive to the bottom roll, and allows slippage between the two bottom rolls, preventing breakage. The friction is driven by gear on an extension to the neck of the bottom pinion, driving into a third spindle, which connects with the bottom backing-up roll through the friction clutch, located midway between the pinion and roll housings. This friction is in duplicate, and is so arranged that the device can be replaced in a short time, should it become necessary. The large backing-up rolls are turned in the mill, places for turning rests being provided in the housing design. These rests are left in position in the housings all the time, and only require adjusting to the roll for use in turning. The 34-in. chill rolls are removed and ground in a special grinding machine which has been built for the Lukens Company by the Norton Company, of Worcester, Mass. This is the largest grinder ever constructed for this class of work. The changing of the 34-in. diameter rolls has been worked out very carefully and incorporated in the mill design. In this operation the rolls are lifted by the top roll balancing cylinders and placed on a specially constructed trolly which runs in on the middle roll rest bars. This arrangement allows the roll to be pulled out of the housing window, where it is picked up by the overhead crane. The 50-in. diameter backing-up rolls are removed in the same manner if at any time this is found necessary.

The bottom pinion is connected to the engine jack shaft by a finely machined leading spindle of the universal type. This connection is to insure a minimum of back lash. This leading spindle is so arranged that it can be quickly removed and a slow motion turning rig slid in place to be used in dressing the 50-in. back-up rolls.

The mill is driven by a twin tandem compound condensing engine having cylinders of 46 in. and 70 in. diameter with a stroke of 60 in. fitted with a jack shaft and a gear ratio of one to two, which renders it capable of giving an enormous torque for rolling wide plates. The engine was designed and constructed by the Mesta Machine Company, of Pittsburgh. The steam for operating this engine is obtained from Babcock and Wilcox waste heat boilers located on open hearth and re-heated furnaces; these boilers are operated at 160 lb. pressure and 100 deg. superheat.

The mill is fully equipped with tables so arranged to do away with hand labour wherever possible. The ingots are received from the furnaces by a hydraulically-operated ingot tilter, from which they go to the approach table, and from thence to the mill tables. The approach table is about 40 ft. long, and the mill tables of about equal length. Each mill table consists of 10 cylindrical rollers and five disc rollers. These rollers are driven by cut gearing, and the bearings and gearings are flood-lubricated by an oil pumping system which is installed in duplicate. These tables are equipped with mechanical appliances for handling large plates, so that it is not necessary for them to be touched by hand power, as is done in other present-day mill practice.

The plates after being rolled, pass over the runout table, 65 ft. long, to the straightening rolls. These straightening rolls were furnished by Hilles and Jones Company, Wilmington, Del., after Mr. C. L. Huston's special design, and are motor driven. After leaving the straightening rolls, the plates pass to the cooling tables. These are mill transfer chain roller tables, arranged so they can be operated in triplicate. Either one, two or three tables are used, depending on the length of the plate transferred. If the plate is over 35 ft. long, two tables are needed; if over 70 ft., three are used. An inspection tilt-up device for turning up the plates so that the bottom side may be inspected is located in this table. It is operated by hydraulic cylinders. This rigging is of the necessary size and strength to accommodate plates 204 in. wide.

After inspection, the plates proceed to the shear runout table through the cut-off shear, which is hydraulically operated, and has a 210-in. gap (see Fig. 2, page 114). The cut-off shear is located in the shearing building, as is also the side shear, which is of the same size, and the necessary scrap shears. Between these shears are located tables specially designed by Mr. C. L. Huston for the handling and turning of wide long plates. These take the place of the usual caster roller arrangement, avoiding hand labour. Another set of transfer chains carry the plates sidewise to the shipping building, where they are weighed and loaded.

The heating building contains eight gas-fired pit furnaces; some of these contain three holes 7 ft. by 9 ft., the others have four holes 5 ft. by 9 ft. This furnace building is served by two 30-ton cranes. The main mill building is 70 ft. by 215 ft., and contains one 75-ton repair crane for the mill. The cooling building is 100 ft. by 240 ft.; the shearing building 80 ft. by 240 ft., and the shipping house, 90 ft. by 505 ft. Two smaller buildings are located on each side of the main mill building.

The mill has a slack-up of 40 in., and it is possible to roll ingots up to 60,000 lb. in weight. All the machinery is constructed with a view of handling these heavy

plates. These large plates are rolled direct from the ingots, but as this has been the practice in the Lukens plant, no serious trouble is experienced from this. When this mill is operating at its full extent, it is estimated that it will have a rolling capacity of 4,000 tons to 5,000 tons per week. The new mill is known as the No. 5 mill, and is located parallel to the present 140-in. 3-high plate mill. The position of the two mills and the arrangement of the tables, permits easy transfer of hot ingots between these two units by means of a transfer buggy. By this arrangement ingots can be drawn from the No. 5 mill and rolled in the 140-in. mill, or *vice versa*.

To supply the increased metal to operate the new mill an additional steel plant comprising six basic open-hearth furnances of 100 tons each has just been finished. There is room for two more furnaces, work on which has been started. The group of eight furnaces presents a distinct open-hearth plant and with these eight new furnaces, Lukens plant will consist of 23 basic furnaces and one acid furnace. The estimated annual capacity will be about 500,000 tons of finished plates.

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—A conference on "The Workers' Interest in Costing: a Factor of Industrial Reconstruction," will be held under the auspices of the Industrial Reconstruction Council on Tuesday, the 28th inst., at 6 p.m., in the hall of the Institute of Journalists, 2 and 4, Tudor Street, E.C.4. The chair will be taken by Mr. Jack Joseph, of Messrs. J. Lyons and Co., Limited, and the opening address will be by Mr. M. Webster Jenkinson, C.B.E., F.C.A., Controller of Factory Audit and Costs at the Ministry of Munitions. Questions and discussion will follow. No tickets are necessary.

THE LATE PROFESSOR MARCEL DEPREZ.—The war and illness have claimed so many victims, that the death of Professor Marcel Deprez, a familiar name in the early days of electric power transmission and of the first International Electric Congresses, has passed almost unheeded. He died after long illness at Vincennes (Paris) last October, in his seventy-sixth year. Born in the Department Louret, he was trained as an engineer, and was already 38 years old when he turned his attention to electrical science, joining Carpentier and d'Arsonval in the manufacture of electric measuring instruments. In 1885 he transmitted 60 h.p. of electric energy by continuous currents of 6,000 volts from Creil to Paris, a distance of 56 kilometres, realising an efficiency of nearly 50 per cent.; high-tension step-up and step-down transformers were used in this transmission. This success helped him to a seat in the French Academy, which elected him a member in 1886. Four years later he became Professor of Electrical Engineering at the Conservatoire des Arts et Métiers. His last years were spent in retirement owing to protracted illness.

DEMOBILISATION AND REINSTATEMENT.—We are informed that the Employment Exchanges, assisted by the Local Advisory Committees which represent equally the interests of both employers and employees in every neighbourhood, have the organisation ready for use in demobilisation and reinstatement. The staffs of the Exchanges have been considerably strengthened in order to meet the extra strain thrown upon them. Branches have been set up to deal with discharged men only, and in a great number of cases special sections for disabled men have been established. As far as possible, the work in these new additions to the Exchange system is carried on by men in the same position as those whom they are helping back to civil employment. Discharged men, with no small proportion of disabled among them, superintend the placing of discharged and disabled men. It has been found that the loss of an arm, of a leg, of two legs, and even of eyesight is no insurmountable obstacle to the performance of efficient work, given employers who will employ the men, and the Exchanges which make use of such men are patent examples of the fact that war, even when it has dealt serious bodily injuries, does not unfit the fighter for successful life as a civilian.

NAVAL HONOURS.—The following honours have, with the approval of His Majesty the King, been conferred upon naval engineers, among others. For Services in Action with Enemy Submarines: Mentioned in Despatches, Eng.-Lieut. G. G. Lemmon, R.N.R., and Art. Eng. H. H. Starkie, R.N. For Miscellaneous Services: Mentioned in Despatches, Eng.-Sub-Lieuts. J. A. Cunningham, R.N.R., and Ernest Massall, R.N.R. Honours for the Mercantile Marine: To receive the Distinguished Service Cross, Chief Engs. C. C. Lapsley, O.B.E., and J. L. Murray. To receive the Distinguished Service Medal, Chief Engs. Albert Gidney, G. F. Irwin, Wm. Snowdon and Lewis Stuart; 1st Engs. K. J. Henderson and John Mulvaney; 2nd Engs. E. P. Bamford, G. A. Linton and W. W. Margarson; and 4th Eng. A. W. M. MacCallum. The President of the French Republic has conferred the Croix de Guerre upon Engmn. Edward Knight, R.N.R., O.N. His Majesty the King of the Belgians has bestowed the Croix de Guerre upon Eng.-Comdr. G. F. H. Parsons, R.N., Eng.-Lieut. F. C. Holt, R.N.R., and Engine-room Art. G. A. Davey; while His Highness the Sultan of Egypt has conferred the Order of the Nile upon Eng.-Capt. H. Lashmore, C.B., D.S.O., R.N.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—At the present time there exists a fairly good demand for steel material of all kinds, and home consumers generally are pressing for delivery. The unsettled state which has recently manifested itself with regard to working hours may militate against things for a little, but wise counsels will eventually prevail, and it is fully anticipated that before long the trade will settle down to a season of good business. Order books are well filled and the immediate prospects of the home trade are quite satisfactory. The demand for sheets is increasing, as large quantities are required for both shipbuilding and railway purposes, and an advance in price in the near future is a contingency which buyers will shortly have to face. The export trade is meantime not of any great consequence on account of the difficulties which still exist. Inquiries, however, are of large volume, and, as the desire is slowly arising to re-enter the old markets, before many months are over our foreign trade will again be opening out. The matter of transport will play a very important part, and freights will require to show an appreciable fall before much can be accomplished. The current prices for home business, in trucks, ex works, are:—Ship plates, 11*l.* 10*s.* per ton; boiler plates, 12*l.* 10*s.* per ton; and angles, 11*l.* 2*s.* 6*d.* per ton.

Malleable Iron Trade.—Considerable activity prevails in the malleable-iron trade of the West of Scotland, and orders on hand ensure steady work for some time. As in the case of steel, the shipping departments are not over-taxed, but a certain number of good inquiries are about. The price of "Crown" bars is 18*l.* 10*s.* per ton.

Scotch Pig-iron.—The demand for Scotch pig-iron continues, and large deliveries are the order of the day. The output is good, but so great is the demand that nothing goes into stock, even with the furnaces working full pressure. Hematite iron is the subject of a steady demand, and the output is readily absorbed. Foundry iron is not over plentiful at present, but is in good request.

Shipbuilding.—The announcement by the Shipping Controller of the removal of shipping restrictions in the near future, and the restoration of pre-war liner services, is expected to encourage the placing of new shipbuilding contracts. The Fairfield Shipbuilding Company, Limited, Govan, has contracted to build two steamers for the Anchor-Donaldson Line. Another contract which has just been reported is one for four cargo steamers for Messrs. Donaldson Brothers, to be built by Messrs. Scotts Shipbuilding and Engineering Company, Limited, Greenock. The deadweight carrying capacity of each of these vessels will be 9,000 tons.

MANUAL OF ELECTRICAL UNDERTAKINGS.—We have received a copy of the Manual of Electrical Undertakings and Directory of Officials, for 1918–19, the twenty-second year of issue. Like the preceding volumes, it is compiled under the direction of Mr. Emile Garcke, M.I.E.E., F.S.S., and is published by the Electrical Press, Limited, 13–16, Fisher Street, Southampton Row, W.C.1, at the price of 22*s.* 6*d.* net. It contains about 1,700 pages of information on all electrical applications, divided up into sections dealing with lighting, power and traction, telegraph and telephone, manufacturing, colonial electrical undertakings, &c. The different undertakings are arranged alphabetically, the particulars given including the population of the town, the dates of legal powers, the system used, the authority in charge, loans, expenditure, reversal, and so forth. Detailed particulars are also included in the case of the manufacturing and miscellaneous concerns. The officials are classified alphabetically in a directory forming part of the book. The manual opens with interesting data on the progress of the year; it contains, further, a large number of maps and plans, a detailed index and a buyers' guide directory.

GAS QUALITY AND GAS-MANTLE EFFICIENCY.—Experimenting on the efficiency of gas mantles in the United States Bureau of Standards, R. S. McBride, W. A. Dunkley, E. C. Crittenden and A. H. Taylor (Technologic Paper No. 110) confirm what will be a fairly general impression, that the lamp adjustments are difficult, and that it is practically impossible to control all the conditions with sufficient exactness to secure a most efficient rate of heat input. When the pressure of the gas is increased above the minimum necessary for keeping the lamp bright, the gas consumption increases, and the candle-power and efficiency rise to a maximum within the pressure range tested, from 1½ in. to 8 in. of water, pressures of from 2 in. to 4 in. answered best. The effect of the gas adjustment was similar to that of the pressure regulation; a lamp adjusted to give maximum light at a certain pressure, yielded a somewhat higher efficiency when readjusted for a slightly lower gas consumption; but the various adjustment devices were by no means uniform over their whole ranges. A gas of high heating value required a wider opening of the air valve to give maximum efficiency than a gas of lower calorific power. The city gas (mixed coal and water gas, calorific power 650 B.T.U.) gave, with lamps of the upright type, slightly higher efficiency than a water gas of about 550 (540 to 575) B.T.U. Water gas of about 540 B.T.U. proved more efficient than coal gas of the same power; city gas enriched with benzene up to 650 B.T.U. and 740 B.T.U. was only little superior to the original gas. When maximum candle-power and efficiency points were selected from various tests performed under different conditions it was found that these maxima were distributed over a wide range of heat inputs.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The unsettled condition of labour, and the excess profits tax are two factors which are acting as a clog on the wheels of industrial progress so far as Sheffield is concerned. Employers are not disposed to launch out in new industries until something more definite is known on these points. The continual demand for shorter hours and advances in wages is producing a feeling of resentment amongst employers. No sooner have they conceded one series of applications than they are faced with another of an even more excessive character. Conferences on the 47-hour week agreed for engineers have only resulted in a formal demand on the part of the unions for a 40-hour week, continuous shifts, with Saturday and Sunday holiday. With every desire to meet the just demand of labour for improved conditions, employers are beginning to despair. At present, the transition from war to peace conditions is progressing much more slowly than was at first hoped. Some departments are very quiet, with little new work coming in. In others, however, orders are arriving faster than they can be executed, and every effort is being made to extend plant and secure labour. The basic and crucible steel departments continue very quiet. Extensive inquiries have been received for open-hearth steel, spring steel, &c., from abroad, but considerable dissatisfaction exists as to arrangements for prices, and only moderate business has eventuated. Rolling mills are busy with work to carry them over a considerable period. In the file and small tool trades extensions are in progress. One of the most prosperous departments in the city's trade is that of agricultural steel. The home demand is very heavy for all kinds of steel and tools for farm and implement purposes, while the overseas demand is steadily increasing. Here, again, however, the price question is causing difficulty, and the stocks ordered are of a less substantial character than would be the case under more favourable conditions.

South Yorkshire Coal Trade.—There has been little doing during the past week, and the general outlook remains unchanged. Best steam hards are in active request by all classes of home consumers, and there is a fairly strong demand for export. Admiralty requirements are still heavy. A substantial tonnage is going to France. The shipments to neutral ports are very light. Cobbles, nuts and slacks are occupying a strong position with contractors' orders taking most of the output. House coals are still scarce, there being a general complaint of shortage. Notwithstanding the setting down of many of the furnaces, cokes are still in strong request, and prices at the maximum. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

WATER POWER RESOURCES COMMITTEE.—Communications intended for the Water Power Resources Committee of the Board of Trade should in future be addressed to the Secretary at Gwydyr House, Whitehall, London, S.W.1, instead of to 10, Princes Street, Westminster, as hitherto.

THE RISE IN THE PRICE OF FUEL.—France, from December 1, has reduced the price for industrial coal. The Germans have found it necessary very materially to raise their quotations for coal, and we append a table showing the upward movements:—

—	Coal.	Coke.	Briquettes.
	marks.	marks.	marks.
January, 1917 ..	2·00	3·00	3·25
October, 1917 ..	2·40	3·60	2·50
September, 1918* ..	2·40	3·40–4·00	2·40
January, 1919* ..	14·50	21·70	14·50

* Including coal tax.

In the Ruhr district a hewer's wage per shift has risen from a daily average of 6·17 marks in 1914 to 10·42 marks in 1917, and for the third quarter of 1918 it has amounted to 13·28 marks.

THE KRUPP CONCERN.—The happenings in connection with the huge Fried. Krupp undertaking illustrates the almost incredible change which the last couple of months have wrought within the leading German industry. The chairman, at the general meeting of the Westphalian Wire Industry Company, which is closely connected with Krupp and whose dividend is regulated according to that of the former, stated that the expectations as regards the Krupp dividend had unfortunately not come true. It had been assumed that the Krupp dividend for the year 1917-18 would be equal to that for the previous year, viz., 10 per cent., but as matters had developed the board had arrived at the conclusion that a dividend of only 4 per cent. could be paid, and even this much reduced dividend could not be defrayed by the year's profits, but would have to be taken from the sum carried forward from 1916-17. Recent events, it is said, had even upset this arrangement, and as a result no dividend at all will be paid by Fried. Krupp for the last financial year. The dividend of the Westphalian Wire Industry Company, however, was fixed at 8 per cent., the Krupp Company consenting without prejudice to its legal rights, present and future.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little news to report concerning the Cleveland pig-iron trade. Demand for foundry kind continues much beyond what can be met, but the quite plentiful supply of forge quality is selling freely. Make of the latter keeps much above the normal, and under existing conditions producers see little prospect of improving the quality of their output. Means of distribution are still far from what could be wished. Whilst the truck shortage cannot be said to be acute, it is sufficient to accentuate irregularity of delivery, and improvement as regards rolling-stock would be very welcome. A temporary reduction in production of pig-iron is reported by the blowing-out of a furnace that has been running on basic iron, making the number of furnaces now in blast 71, but as an idle furnace is to be restarted immediately—probably on Cleveland iron—the lessened output is small. Export trade is quiet. So far as is ascertainable there are still no transactions with neutrals, and even with France business is on a smaller scale; whilst negotiations with Italy appear, for the present to be at a standstill. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; and for export, No. 3 and the lower qualities are 145*s.* and No. 1 is 150*s.*

Hematite Iron.—Some little improvement is noticeable in the East Coast hematite situation. Whilst continued heavy urgent home demand absorbs the bulk of the make, a little iron is available for export. All home needs are now receiving adequate attention, and some expansion of foreign business is looked for. Of course, any increase in make would still be very acceptable. Distribution is still controlled, Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use and the export price is 172*s.* 6*d.*

Foreign Ore.—There is not much new business passing in foreign ore, consumers having very considerable stocks, and deliveries against contracts made being on quite a satisfactory scale, but there are a fair number of inquiries, and occasional sales are reported.

Coke.—Coke keeps scarce, but the deliveries to the blast furnaces leave little room for complaint under present conditions. Medium furnace kinds are 33*s.* at the ovens, and qualities low in phosphorus 35*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Labour disputes are having a disturbing influence on the manufactured iron and steel industries, and have occasioned a few interruptions. Producers have excellent order books, and there are numerous inquiries in the market, demand for railway material, and constructional steel, being particularly pronounced. With labour difficulties removed, prospects in finished iron and steel would be very bright. To home customers, the following are among the principal market quotations:—Common iron bars, 15*l.* 10*s.*; iron ship rivets, 22*l.*; steel ship, bridge, and tank plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; chequer plates, 13*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy sections of steel rails, 10*l.* 17*s.* 6*d.*; and steel billets, 10*l.* 7*s.* 6*d.* to 11*l.*; and export prices include: Common iron bars, 20*l.*; steel ship, bridge, and tank plates, 16*l.* 10*s.*; steel angles, 16*l.* 2*s.* 6*d.*; steel boiler plates, 17*l.* 10*s.*; chequer plates, 18*l.*; steel joists, 16*l.* 2*s.* 6*d.*; heavy steel rails, 15*l.* 10*s.*; and steel billets, 13*l.* 10*s.* to 15*l.*

RADIO-ACTIVE SUBSTANCES, LUMINOUS BODIES AND ORES.—The Minister of Munitions has suspended until further notice the Radio-Active Substances (Control) Order, 1918, which prohibited dealings without a permit and required returns.

PHOTOGRAPHIC MORDANT DYE PROCESS.—Five years ago Traube patented the first mordant dye process that attracted attention. He showed that a metallic silver image, converted into silver iodide, became strongly coloured when immersed in a solution of a basic dye; he fixed the dye by tannin, dissolved the silver iodide out and thus obtained a transparent dye image. The process was improved by Tanleigne and Mazo, who first hardened the gelatin with alum and treated the silver iodide image with a strong solution of potassium iodide; the dye image then became so transparent that it was unnecessary to wash out the silver iodide image. It was further discovered that silver ferrocyanide and chromate and other silver salts could be substituted for the iodide, but the results were not very satisfactory. Vanadium-toned images and copper-toned images can likewise be mordanted, Crabtree and Ives pointed out; but the reddish colour of the copper-ferrocyanide image made this method unsuitable for blue and green dyes, though it answered for orange-red tones. F. E. Ives describes, in the Journal of the Franklin Institute of December last, a new efficient chromate mordant dye process. He is evidently thinking of photographic three-colour processes, though he does not mention that point. He bleaches the silver image in a solution containing 1 oz. each of potassium ferrocyanide and of chromic acid in a gallon of water. A pale yellow transparent image is produced which has a strong affinity for basic dyes; this image is washed under the tap to remove the chromic acid which might over-harden the gelatin, and to hasten the washing process as well as for other reasons a little sodium bicarbonate is added to the water. A good dye is obtained by dissolving 10 grains of saffranin in 4 oz. of alcohol; water acidified with acetic acid is added, and the plate immersed for half an hour and then washed in water with a little acetic acid. Malachite green and auramine are other suitable dyes.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Considerable interest was evinced on the markets to-day in the official announcement that the supply of coal under Admiralty contracts to the French and Italian Government services through the local Admiralty agents will cease at the end of the present month. In the communication addressed to the Coal and Coke Supplies Committee, the local Admiralty agents state that in future any tonnage which the Minister of Shipping provides for distribution among the French and Italian Government services will be notified by them to such services, and they presume that in future the French and Italian Governments will make their own arrangements as regards the provision of cargoes and payments for them. It is not quite clear how far this announcement restores freedom of coal chartering in connection with shipments to France and Italy, or how it affects the buying and selling arrangements of those two countries. It is also officially announced that the arrangement under which small coals have hitherto been supplied to patent fuel manufacturers for the production of patent fuel for home consumption is now cancelled, and that henceforth the price of small coals must be in accordance with the terms of the Price of Coal Limitation Act, that is, 13*s.* per ton above the prices for the corresponding quantities and qualities in the year immediately preceding the war. The most unsatisfactory feature of the markets is the stationary character of the outputs from the collieries. Since the signing of the armistice about 15,000 miners have returned to the South Wales mines, but production does not seem to have been affected favourably to any appreciable extent. Indeed, it was stated on the market this week that in the case of one colliery where 500 demobilised men had been re-employed, not a single ton had been added to the output. Complaints are also being made of absenteeism which, in the last week of December, was as high as 14½ per cent. The pitwood position is unchanged, but the Allocation Committee are performing their work so efficiently that no stoppages have yet resulted through lack of timber.

Newport.—Business in Monmouthshire coals has been almost exclusively of an official character. Shipments, however, are active, and increasing quantities of coal are being released for export wherever possible. Demands from foreign consumers are increasing, but the conditions governing the placing of contracts are restrictive in effect, and pressure is being brought to bear with a view to their relaxation at the earliest possible moment.

Coals for Neutrals.—In September last the Coal and Coke Supplies Committee for South Wales and Monmouthshire decided upon a scheme for the allocation of orders in connection with the supply of coal to neutrals. Those orders were distributed proportionately to the amount of business done with neutrals by individual collieries over a certain period determined by the committee for the purposes of selection, and the surcharges on the scheduled prices have varied from month to month. During last December the surcharges were 5*s.* for large coal, 6*s.* for through coal, and 10*s.* for small coals, and for the present month a decision was arrived at increasing the surcharge, in the case of large steam coal to 15*s.* per ton, making the neutral price for best steam coals 65*s.* per ton, as compared with the fixed price of 40*s.* for the Allies. It is understood that in view of the altered conditions on the freight and coal markets, this scheme has now been withdrawn, and that there will be no further allocations. The effect of this decision is that henceforth the market for neutrals will be free of the conditions previously imposed by the Coal and Coke Supplies Committee, and that the only limitations remaining are those contained in the Coal Controller's directions of October last.

ELECTRICAL RESISTANCE OF SUSPENDED WIRES.—In 1887 the late Shelford Bidwell described some experiments on vertically-suspended wires through which an electric current was passing. He observed that, when the current travelled upward, the resistance of a copper wire was slightly greater than when the current was flowing downward. In the case of an iron wire, the resistance was greater for the downward current. The effects were so small that Bidwell hesitated to publish the observation; he ascribed the changes to thermal (Peltier) effects in the wires stretched by their own weight. The observations are confirmed by experiments described by S. R. Williams, of Oberlin College, Ohio (*Physical Review*, September, 1918, pages 243 to 250). Williams suspended wires so as to form an inverted U or V, connecting the free lower wire ends with a Wheatstone bridge. Such a wire would be more stretched in its higher portions near the point of suspension in the middle, than below, and a current would travel from an unstrained to a strained portion up the one leg, and from a strained portion to an unstrained portion down the other leg. Changes in the resistance of the wires and temperature differences should hence arise, and these latter amounted to about $\frac{1}{10}$ deg. C. in the experiments described. Though stating that the experiments should be made with long wires, Williams gives no information about the length of his wires. He mentions that he had to use insulated wires (silk-covered), as the air currents made the effects too irregular, and that he attached weights of 175 grammes to different points of his wire to increase the stretching; how this was done, is not explained. Direct temperature measurements were made by winding an exploring coil round a bared portion on each leg and by bringing thermocouples up to these portions; these measurements confirmed the temperature differences deduced from the resistance determinations.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 24, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Papers: "Electric Welding," by Mr. T. T. Heaton, of Uxbridge, Member; "The Development of the Oxy-Acetylene Welding and Cutting Industry in the United States," by Mr. Henry Cave, of Hartford, Conn.; "Oxy-Acetylene Welding," by Mr. J. H. Davies, of the Central Technical School, Leeds; and "Oxy-Acetylene Welding," by Mr. F. Hazledine, of the London and North-Western Railway Works, Crewe.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, January 25, at the Grand Hotel, Aytoun-street, the evening will be reserved for a discussion on "The Past, Present and Future of Electricity Supply." The discussion will be introduced by Mr. S. L. Pearce, C.B.E., M.Inst.C.E., M.I.Mech.E., M.I.E.E. (Chief Electrical Engineer, Manchester), and Mr. J. A. Robertson, M.I.E.E. (Chief Electrical Engineer, Salford). The chair will be taken at 6.30 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS.—Monday, January 27, at 7.30 p.m., a special meeting will be held at the Royal Society of Arts, John-street, Adelphi, W.C., to discuss the question of "National Electricity Supply." Speakers: Mr. W. H. Patchell, M.Inst.E., Mr. W. A. Tookey, M.I.Mech.E., and others.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 28, at 5.30 p.m. Paper to be submitted for discussion: "Centrifugal Pumps for Dealing with Liquids containing Solid, Fibrous and Erosive Matters," by the Hon. Richard Clere Parsons, M.A., M.Inst.C.E.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LEEDS CENTRE).—Tuesday, January 28, at 7 p.m., in the Philosophical Hall, Leeds. Paper by Mr. T. Thompson, Darlington, on "Locomotive Building Practice."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Tuesday, January 28, at 7 p.m., in the Philosophical Hall, Park-row, Leeds, when a paper by Mr. T. Thompson, North-Eastern Railway, Darlington, entitled "Locomotive Building Practice," will be read and discussed.

THE ROYAL SOCIETY OF ARTS.—Wednesday afternoon, January 29, a paper on "Food Production by Intensive Cultivation" will be read by Mr. Frederick Keeble, C.B.E., M.A., Sc.D., F.R.S., Controller of Horticulture, Food Production Department, Board of Agriculture and Fisheries. The chair will be taken at 4.30 p.m. by the Right Hon. Lord Lambourne, C.V.O.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, January 30, at 3 p.m., at the University, Leeds. A paper on "The Petrography of Sedimentary Rocks, with Special Reference to the Coal Measures," will be read by Dr. A. Gilligan, F.G.S. The papers on "Some Economic Considerations in Coke Oven Practice," by Mr. W. Colquhoun, and "The Training of Students in Coal Mining, with Special Reference to the Scheme of the Engineering Training Organisation," by Professor F. W. Hardwick, M.A., will be open for discussion.

THE BIRMINGHAM METALLURGICAL SOCIETY.—Thursday, January 30, at 7 p.m., at the Birmingham Chamber of Commerce, New-street. Paper by Mr. W. J. Rees, F.I.C., the University, Sheffield: "Silica Refractories."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 31, at 5.30 p.m., a discourse will be delivered by Professor H. H. Turner, D.Sc., D.C.L., F.R.S., F.R.A.S. The subject will be "Giant Suns." Afternoon Lectures, at 3 p.m.: Tuesday, January 28, Professor Spenser Wilkinson, on "Lessons of the War" (Lecture III); Thursday, January 30, Professor J. Norman Collie, LL.D., F.R.S., on "Chemical Studies of Oriental Porcelain" (Lecture III); Saturday, February 1, Professor Hugh Percy Allen, M.A., Mus.Doc., on "The Works of J. S. Bach" (with musical illustrations) (Lecture I).

SHEAR TEST FOR CAST IRON.—A novel method of testing cast iron is briefly described by C. Frémont in the Comptes Rendus of December, 1918. Rightly objecting that cast iron tests are generally performed on specially-cast specimens which are not cast and cooled under the actual conditions, under which the piece in question has been prepared, Frémont proposes a way of detaching small specimens directly from the piece and of submitting them to a shear test in a new small machine of his design. By means of a trepanning tool he isolates a cylinder, about 25 mm. diameter and 20 mm. high from the actual piece; this cylinder is then detached from the piece with the aid of two centre tubes. The specimen thus obtained weighs about 5 grams, against specimens of one or several kilograms' weight wanted for tensile and impact tests. The specimen is placed within a block holding a fixed blade and cut by a movable blade which is forced into the specimen by a weight acting on a lever; the force of rupture is estimated from the weight and leverage as traced by a style. The machine is also recommended for testing cement. Frémont considers that the small weight of his specimen, which can serve for several tests, is a great advantage, and that his shear-test values are the same as those of the tensile-strength test while being free from the objections to the latter. His description is not sufficiently detailed, however; he does not give any results, and cast iron can hardly be judged by a few tests of small specimens.

204-IN. PLATE ROLLING MILL AT THE LUKENS STEEL COMPANY'S WORKS.

CONSTRUCTED FROM THE DESIGNS OF MR. PAUL C. HALDEMAN, AND OF THE UNITED ENGINEERING AND FOUNDRY COMPANY.

(*For Description, see Page* 110.)

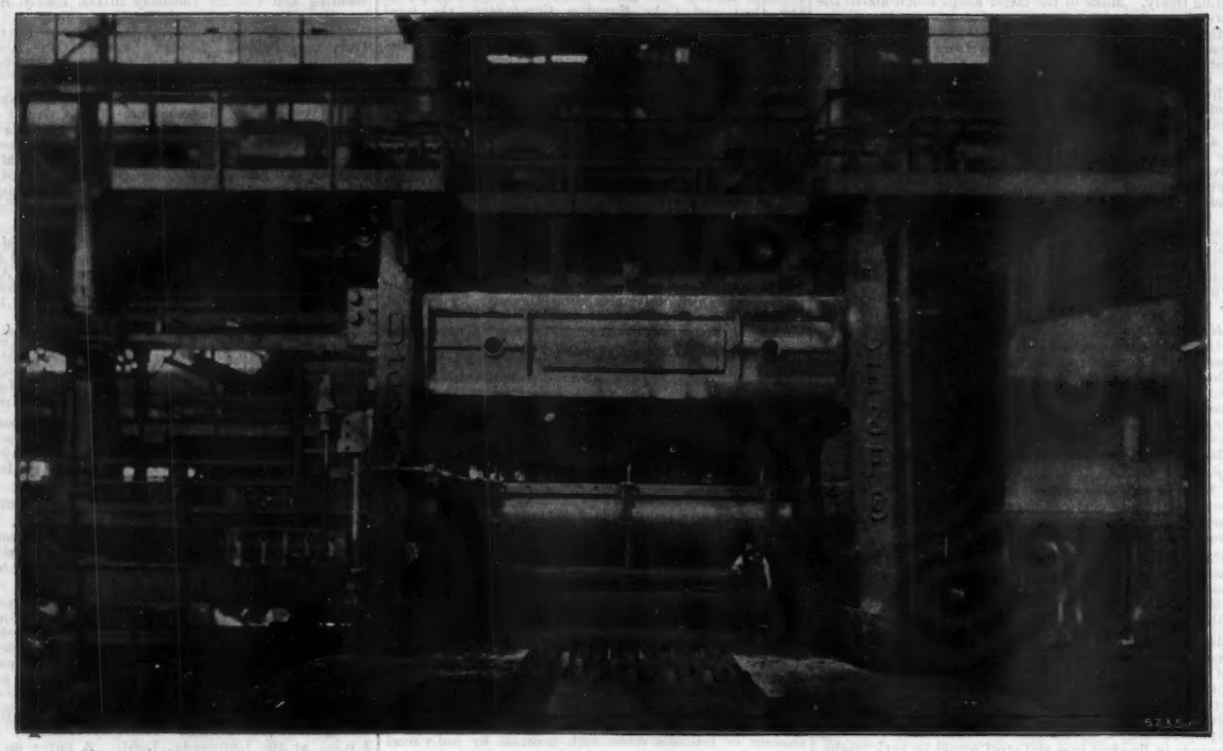


FIG. 1. THE MILL.

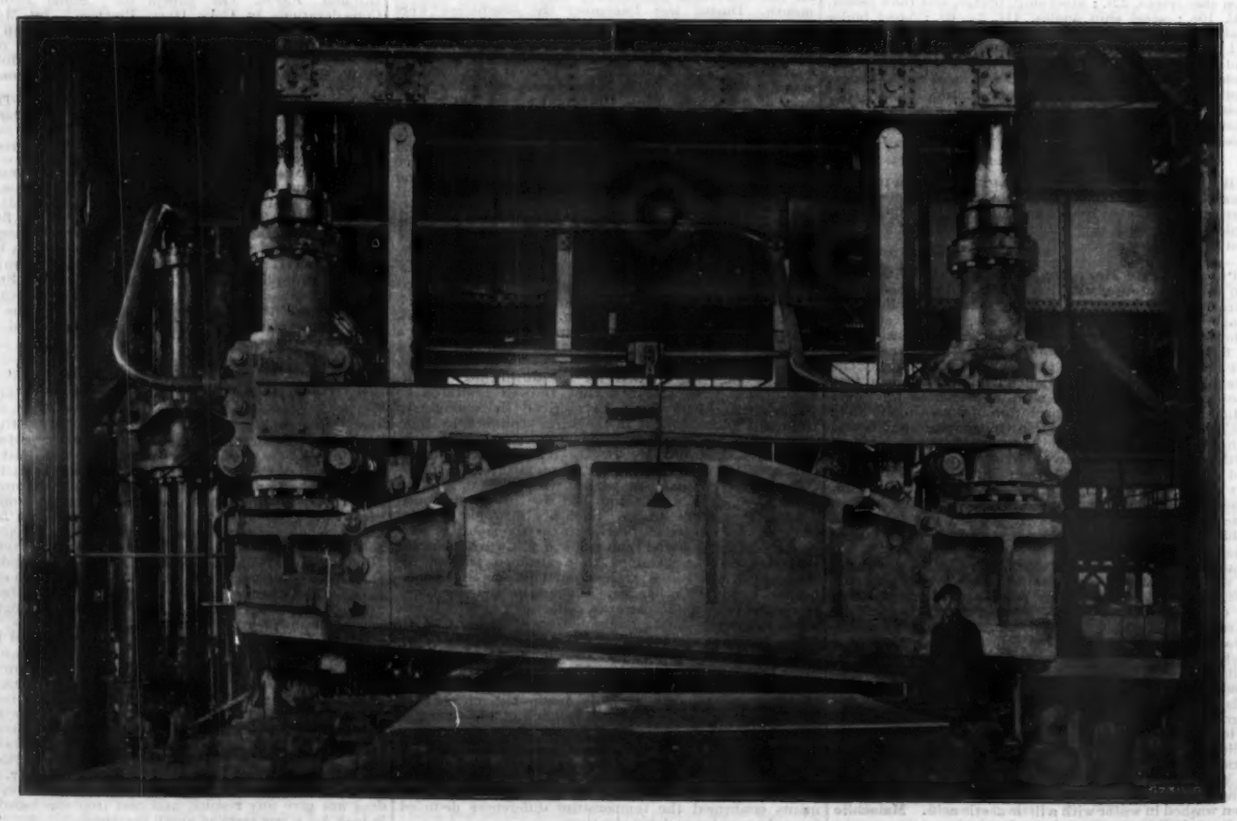


FIG. 2. THE SHEARS.

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With Two Two-Page Plates of the BRITISH CHANNEL TRAIN FERRY STEAMERS.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 113.

ENGINEERING.

FRIDAY, JANUARY 24, 1919.

COMMERCIAL AIR SERVICE.

WE are on the threshold of an enormous commercial air service. Every newspaper is full of it, and the immense array of engineering and scientific knowledge which, during the past four years, has been directed to securing us the command of the air in a military sense, is now busily engaged in working out plans for passenger and postal services to all parts of the world. At the same time it is understood that the great congress of statesmen gathered in Paris are turning their attention to defining the conditions under which international service must be conducted so as to avoid accidents, and to conform with various customs regulations.

Among the early work that needs to be done, there arises first the demarcation of the spheres which pertain respectively to the airship and the aeroplane. The public in this country have, somewhat naturally, come to look upon the airship as an inferior structure, and have reserved their enthusiasm for the aeroplane. The remembrance of individual Zeppelins falling in flames near London, and the account of a fleet of them drifting helplessly across the North Sea and into France, give rise to misgivings as to their safety. But it must be remembered that these incidents took place under war conditions, and in an earlier stage of development. The invention of the incendiary bullet sealed, for the time at any rate, the career of the Zeppelin as a bombing instrument, for it put it at the mercy of the aeroplane, which was nearly twice as fast and infinitely better at manœuvring. The loss of the fleet was ascribed to the freezing of the water in the radiators, an accident not likely to occur again, once the danger was appreciated. Neither of these incidents is of any importance in estimating the future of the airship as a commercial vehicle. Further, while everything likely to discredit the German airship was published broadcast, it was not until after the armistice that anything could be printed in explanation of the splendid results attained by our own airships in their daily patrol of the Channel in search of the trail of the submarine. Those living on the coast saw them go and return morning and evening, but they knew little of the scenes that occurred—most exciting both for hunter and quarry—when the U-boat's course was dogged for hours and its structure shaken by repeated explosions of depth charges. In this work the airship was far more efficient than the aeroplane, since its peculiar weakness, from a military point of view, of inflammability was of no consequence when its opponent dared not come to the surface to use his guns.

We won our command of the air by the aeroplane, and we utilised it to harry our enemy on the march, to bomb his railways and stations, to fire his ammunition dumps and to terrorise his towns. For none of these purposes was the airship so suitable, but we must not allow a former state of affairs, now happily at an end, to colour unduly our judgment when we turn and survey our future prospects in the air. Naturally manufacturers of various flying craft declare that there is nothing like leather, and undoubtedly there is a great future both for the heavier-than-air and the lighter-than-air machines. It is easy to point to conditions in which each will be easily pre-eminent, but it is not so easy to lay down a dividing-line between the two services. At a time when progress is most rapid, when bigger and bigger machines are being constructed, and designs are being got out for sizes not yet attempted, it is, of course, dangerous to dogmatise and to lay down rigid limits; but nevertheless there are certain scientific principles which are beyond dispute, and which afford clear guidance up to a certain point. One is that in similar structures the strength is inversely proportional to the linear dimensions. If we apply this to aeroplanes we see that if we double the span of the wings and still maintain the structure proportionally strong, the weight will be increased four times, and if the width of the wing structure be correspondingly doubled the weight of the whole will be multiplied eight times. Thus the lift will be increased four times while the weight will have grown to eight times its former amount. The useful lift of an aeroplane of average engine power is one-third its weight, and increased weight demands largely increased engine power, which, of course, has also to be lifted. All-round efficiency is measured by the ratio of disposable lift to total lift, and this tends to decrease with greater dimensions. Greater efficiency will not be found in increase of size, but must be sought in progress in design and materials. What these may bring in the future we cannot say, but for the present the special features of the aeroplane mark it out for journeys of 500 to 800 miles at one flight.

The outstanding merit of the aeroplane is its speed. A sustained velocity of 125 miles an hour has great attractions for the busy traveller, and for its sake he will put up with cramped quarters and deafening noise for a few hours. He may even repeat his experience for three or four days, but if he demand four or five hours for rest and change of position at each landing the average speed will be greatly reduced, and he will begin to weigh the relative advantages of the aeroplane and the airship. With the latter a range of 3,000 miles, or from London to New York, at a speed of 60 miles to 70 miles an hour is quite a possibility, and combined with that is an amount of freedom and comfort quite impossible in an aeroplane. The law of similarity, which operates so adversely to the aeroplane, assumes another aspect in relation to the airship. The former depends for its lift on its area, while the latter depends on its volume. To take a concrete example from a recent publication of the Air Ministry* a 10,000,000 cub. ft. capacity rigid airship has five times the lift of the present one of 2,000,000 cub. ft. capacity, but its length is only 1·7 times greater, and, therefore, the weight of the structure is only five times greater, that is, the weight of the structure is directly proportional to the total lift. The total lift varies as the cube of the linear dimensions, while the air resistance and brake horse-power, other things being equal, vary as the square of the linear dimensions. Hence, the ratio of weight of machinery to total lift decreases automatically. The coefficient of tractive resistance varies in the case of the 60-ton rigid ship from 1·9 per cent. at 45 m.p.h. to 7·7 per cent. at 80 m.p.h. In the case of the 300-ton machine it varies, under like conditions, from 0·9 per cent. to 3·6 per cent. With a proportionate increase in horse-power it is easier, and proportionately more economical, for a 10,000,000 cub. ft. capacity rigid airship to fly at 80 m.p.h. than for a 2,000,000 cub. ft. ship to fly at 60 m.p.h. In the case of aeroplanes, increase in size effects no decrease in the coefficient of tractive resistance.

It is the inherent difference between the two types of aircraft which marks out the airship for non-stop voyages of long duration. The bigger it is the less its resistance proportionately, and the less weight of engines and petrol it must carry relative to its size. An airship of 3,500,000 cub. ft. capacity could be built now and could carry 15 tons of passengers, mails, &c., for a distance of 4,000 miles at a speed of 60 m.p.h. This is a greater distance than any passenger is likely to ask for without a break, and therefore would fulfil all requirements for a long time to come.

We have before us drawings and specifications

* "Notes on Airships for Commercial Purposes." T.S. D 1385/8467. January 9, 1919.

of such a machine got out by a firm widely experienced in all kinds of aircraft. From this we learn that the ship would have a normal total lifting power of 105 tons, with a disposable lift of 68 tons. The total engine power would be 3,500 b.h.p. and the speed at full power 75 m.p.h., while the normal flying speed would be 60 m.p.h. with 2,000 b.h.p. The time taken from London to New York would be, *via* the Azores (3,600 miles) 60 hours, and by the direct route (3,000 miles), 50 hours.

Of course, the speed is dependent on the wind. On the direct route this is almost always from west to east, and is an assistance on the journey from New York to London. On the westbound journey it will probably be better to follow the line of Portugal and the Azores where the prevailing westerly winds of the higher latitudes are absent. Time and experience will show the best course to follow.

It is calculated that the capital required for four airships, two double sheds, workshops, working capital, &c., would be 2,600,000*l.*, and that a charge of 4*d.* per mile for passengers and 3*d.* per ounce for mails would pay 10 per cent. on the capital, allowing for writing off the airships in three years and the sheds in 30 years.

A three days' journey calls for considerable comfort if it is not to be very wearisome. The designs of the airships provide a great deal more space and liberty of motion than is found on an American transcontinental train. The cabins are all on the top of the ship. The day apartment is to be like a Pullman car, with easy chairs and glazed sides, through which the passenger can gaze, although this is an amusement which is likely to pall very soon. The sleeping cabins are forward of this, as is also the smoking-room. Aft there is a shelter-deck. An elevator runs through the body of the ship, its lower end being in the keel, which extends nearly the entire length, having an observation car at one end, and a control car, for the captain and officers, at the other end. There are to be six engines of a nominal 600 h.p. each. It will be seen that the passengers will have the opportunity for air and exercise both in fine and bad weather, and that their comfort has been carefully studied.

Of course, an aeroplane could be built to cross the Atlantic and probably at somewhat greater speed, but it could not do so without intermediate stops. From Ireland to Newfoundland is 1,800 miles, and from the Azores to Newfoundland 1,300 miles. The latter distance is much the shorter if it were certain that the aeroplane would find the islands every time. They are, however, quite small, and are far out in the Atlantic, and in bad or foggy weather time might be lost in locating them, unless wireless stations giving directional rays be established in the near future. It is more probable that the longer course direct to Newfoundland will be preferred for a regular service. An aeroplane to run on the service would probably weigh 40 tons, and have a useful lift of 20 tons for fuel, oil, passengers, &c. It would require 4,000 h.p. to attain a flying speed of 85 m.p.h. at a height of 5,000 ft. Assuming that 20 passengers were carried the time occupied would be:—London to Ireland, 3½ hours; Ireland to Newfoundland, 21½ hours; Newfoundland to New York, 13 hours; total time in the air, 38 hours, to which must be added two in Ireland and six in Newfoundland for landing, refilling and getting away, or 46 in all.

It is calculated that to carry out the same service as already proposed for the airships, that is, 30 tons of passengers and mails each way per week, 14 aeroplanes would be needed in service and the same number as stand-bys. The total capital required would be 3,860,000*l.* to cover machines, sheds, land, workshops, wireless equipment, &c. Taking the useful life of the machines at three years, and of the sheds at twenty years, and the interest on capital at 10 per cent., the annual charges of all kinds would amount to 1,758,800*l.*; to cover this the passenger charge must be 9*d.* per mile, and the postal charge 7½*d.* per ounce.

A detailed comparison of this kind brings into prominence the difference between the two types of air service. The aeroplane has the advantage in speed and it is the less dependent on weather. On the other hand, it requires relatively much more power, since it has to support itself in the air, and it must make stops at intervals to take in petrol and stores. It is more liable to forced landings, even when it has two or more engines, and it offers little in the way of comfort. In moderate-sized machines, capable of 120 m.p.h., and travelling almost entirely overland, the speed will offer great attractions and will secure for it passengers for trips up to 700 miles or 800 miles. Under these conditions the excess of cost will not be anything like that set forth above, since a greater relative weight of passengers can be carried owing to the supply of petrol being less. For long journeys, however, the airship offers very great advantages. It is daily becoming less subject to weather, and if it cannot satisfactorily face a severe gale it can often avoid it, either by going to a greater height or by going round it. The characteristics of cyclones are now fairly well understood, and it is known that they are seldom of more than 200 miles in diameter. The captain of the tramp steamer knows how he should steer to get out of them, and it should be possible for an airship, equipped with wireless and in touch with every vessel between here and America, to avoid many a gale. The risk of breakdown is exceedingly small, since any one, or more, of the engines can be entirely overhauled and replaced while the ship is in the air. The increase of efficiency of the engine power at slow speed enables the radius of action to be enormously increased, if necessary, unless the ship is battling with strong head winds. In any case the wireless would bring assistance in a few hours, and the airship is not subject to sudden disasters like the breaking of a wing or an elevator. Passengers would not only have very ample comforts and opportunities for exercise, but they would also be free from the nervousness which, for some time at any rate, will be felt by most who travel by aeroplane.

The airship is not without its own special difficulties. On starting its voyage it will float in equilibrium at some determined height, say 5,000 ft. As it proceeds it will rise, due to the reduction of weight of stores and petrol, and it will enter strata too cold for the comfort of passengers, and too attenuated for the best working of the engines. At the same time there will be a periodic expansion and contraction of the hydrogen due to the variation of day and night temperatures, and any expansion beyond a determined limit will involve loss of gas through the automatic relief valves. The contraction of the gas may be met by the discharge of water ballast, and the expansion by opening the valves, but it is evident that these means are undesirable, and could not be used indefinitely. It has therefore been proposed to use the surplus gas as a fuel in one set of engines, and thus to recover a part of its cost. At the present price of 10*s.* a thousand feet it is a dear fuel, but this price is likely to be halved in the future. Another device proposed is to condense the exhaust vapours from the engines, and to store the water, which would about balance the weight of petrol used, and thus go far to maintain the equilibrium.

There remains the difficulty of dealing with the airship at rest. Many have been wrecked when stationary, or when trying to enter the sheds. It has been found, however, that the simplest means of mooring is the best, and that an airship will lie to an anchor just like a steamer, provided she has space to swing bows-on to the wind, however it may shift. Of course, it cannot be anchored to the ground, but must be tied to a high tower, and it is designed to equip the terminal stations with such towers, provided with hauling gear, and with elevators through which passengers can rise to gain access to the ship as she floats.

There is a great future both for the airship and the aeroplane, and room for both to develop side by side. Each has its field lying open to it, and even if it be difficult to define the boundary line between them, there need be no dissension on the subject. Time will show where it lies. At present the pressing need is to utilise our splendid resources for establishing an air service which shall be the equal of our marine, and make us the carriers of the world in the air, as we have been on the sea. More than this, we must still keep the command of the air in a military sense. It is no longer sufficient for us "to rule the waves," since another path has been opened to our shores, but we must also hold the hegemony of the air. As matters stand we do not see how a successful invasion could be undertaken in the sky, but only those who have surveyed the damage wrought by our airmen on an army on the march can estimate the suffering and damage that would be inflicted on us if a future enemy could range at will over the land. In spite of any League of Nations, we shall not be left in easy control of the air, and our future safety lies in our doing our utmost to attain to a vast commercial service. This cannot be attained by the aeroplane alone, as many are prone to imagine; the airship will demand greater attention and outlay than it has hitherto received, and will amply repay them.

LIQUID AIR AND THE WAR.

THE introductory words, with which Sir James Dewar, F.R.S., opened the season of Friday discourses last week at the Royal Institution, did not come as a surprise to the large gathering. When the war broke out, he stated, the managers had placed the Institution and its laboratory at the disposal of the Government and of scientific enquirers, and with the depletion of the staff the continuation of research had become more and more difficult. Thus members would, he was afraid, have to suffer a repetition of old experiments in his discourse on "Liquid Air and the War." Before proceeding to his special subject, however, Sir James referred to the general aspect of the war growth of chemical industry over here and in Germany, quoting in this connection from the address which he had delivered as president of the British Association meeting held at Belfast in 1902. Comparing the chemical equipments of the two countries he had pointed out that, notwithstanding the immense range of industries, in which the United Kingdom had once stood prominent, and the abundance of raw materials, of capital and of brains, we could not then show more than one-third of the professional staff employed in Germany, and had 31 per cent. of systematically-trained chemists against 84 per cent. in Germany. The appalling thing was not that Germany had seized the one or other chemical industry; but they had over there reached a point of general training and specialised equipment which it would take us two generations of hard educational work to attain. For the explanation of the disastrous situation was in one fact: want of education. Sir James saw no reason to change the conclusion he had drawn at Belfast—which had met with a peculiar reception by the intellectual Press of the day, as he proved by some quotations. Comparing Tyndall's address, also given at Belfast in 1874, and Professor Dewar's it had been stated that science has properly shifted its ground from theory to practice! Professor Dewar's address had mainly dealt with the theoretical value of low-temperature research.

Passing to the liquefaction problem, Sir James rapidly reviewed the various methods by which low temperatures had been produced, and the liquid air had been separated into its constituents, first by the aid of special cooling agents and of compression and expansion, and later by application of the principles of distillation, fractionation and regenerative cooling. He then demonstrated some of the characteristic properties of liquid oxygen. There were, in the spectrum of the slightly-bluish liquid, some well-defined absorption bands which resembled in a sense those of chlorophyll, the substance so all-important for plant life. That liquid oxygen is magnetic was shown by letting drops of the liquid fall through the pole gap of a powerful electromagnet; as long as the field was not excited, the drops which were illuminated by the beam falling through the holes of a rotating shutter kept separate; when the current was on, the liquid formed a continuous stream which was drawn to the one pole. Falling on a glass tray the drops darted about in the spheroidal state like snakes, their tails being formed by the streams of condensed atmospheric moisture clinging to the rapidly-evaporating spheroids. Falling on concentrated sulphuric acid, the drops remained almost stationary and seemed

to turn into black discs; what happened was that the sulphuric acid froze under each drop; the solid acid was not transparent to the light rays entering from below, and as the acid absorbed the moisture, mists and tails hardly formed. A piece of faintly-glowing coal thrown on liquid oxygen glowed brightly and burned even when dipped into the liquid; the experiment was an illusion in so far, Sir James remarked, as there was no combustion in the liquid, since the coal did not really come into contact with the liquid oxygen, but only with the vapour. A piece of cotton wool, soaked in liquid oxygen, puffed away like guncotton when ignited.

Some of the most important applications of the liquid air industry, Sir James proceeded, had grown up before and during the war owing to the fact that some use had had to be found for the vast amounts of nitrogen which the isolation of the oxygen yielded. In the first instance the nitrogen had either been bound directly by calcium carbide to produce calcium diamide (to be utilised as fertiliser or as a source for ammonia), or the nitrogen was oxidised in electric furnace to nitric acid. Then Haber had worked out the synthetic ammonia process, and in that again, as in the hydrogen industry in general, low-temperature played an important part. For the hydrogen, obtained from water by electrolysis or from water gas, had to be freed of impurities that would ruin the catalysts, and the impurities were frozen out with the aid of liquid air. This industry had taken an enormous development in Germany during the war, and had become a national monopoly. One plant alone had a capacity of 100 tons of liquid air per day, which represented nearly the total production of liquid air in this country, which was estimated at 118 tons per day, and made in a dozen works. Half of the oxygen (up to 53 per cent.) had been used for cutting armour plates and boilers, &c., and for welding with the oxy-acetylene blowpipe; some of the photographs exhibited by Sir James exemplified the huge scale on which these operations are carried on by the British Oxygen Company.

Professor Dewar then drew attention to novel apparatus—some of German make—which deliver oxygen at definite, adjustable rates for feeding the blowpipes as well as for inhaling and for general hospital work. Some of these apparatus had been recovered from German flying machines, on which their light weight was advantageous. The apparatus consisted of spherical or cylindrical vacuum-jacketed Dewar vessels or thermos flasks which were provided with a safety valve—simply an outlet for the oxygen which was quietly boiling away—and some device for sending the oxygen at a regular rate through a coil surrounding part of the apparatus and in which the oxygen was heated before delivery. The coil might be heated by an electric current supplied by a battery; Sir James showed that by adjusting the resistance of the circuit a flask could be made to give 2 litres or 4 litres of oxygen per minute. In another type there was no artificial heating or elaborate mechanism; a rod of copper or aluminium, which was provided with a screw thread, was gradually screwed into the upper portion of the vessel; as the rod descended, the liquid was forced into a special part of the vessel and into the coil which, being thin walled, was warmed by the air about it; the top of the rod had the shape of a cross so as to facilitate the screwing operation. In a third type a special valve or stop-cock was provided, in addition to the escape; the valve was normally closed, and was made to resist a pressure of about 2 atmospheres, the usual pressure in the oxygen container; when the apparatus was to be used, the stop-cock was opened to the desired extent by turning a milled head, and the oxygen was then siphoned off into a small operating chamber and escaped through a thin-walled copper coil which was warmed by the air about it. To minimise the loss of oxygen from these apparatus, they were best made as large as possible and spherical in shape so as to have minimum surface. Metal was preferable to glass as being less breakable. Experimenting with vessels made of copper and aluminium, Sir James found that with copper there was hardly any loss of gas for the first 5 hours after filling the vessel, which involved a loss of about 40 cub. cm. per litre of oxygen; afterwards the loss increased. With aluminium, the initial gas loss was smaller, but there was a more steady increase in the loss. Large 5-gallon (23 litres) vessels lost only 5 per cent. of their oxygen contents in a day. Before the war 30-gallon copper vessels, of German make, had been offered in this country, and Sir James knew of one of these which had been in continuous use since then and was still doing good service. The vacuum jackets of these vessels were improved by putting a little charcoal in them. Now 5 grammes of charcoal could in 10 minutes reduce the pressure of 300 cub. cm. of air from 1·6 mm. of mercury to 0·0595 mm. and to 0·00047 mm. in 40 minutes (when the charcoal was cooled in liquid air), to 0·0000154 mm. in 10 minutes (when cooled in liquid hydrogen), and even to 0·0000058 mm. in 10 minutes (when in solid hydrogen); very perfect vacua could hence be obtained in this way. To exemplify this, Sir James showed a Crooks' radiometer experiment. A glass tube ended in two bulbs, a big bulb containing a radiometer, and a little bulb containing a drop of mercury. When this bulb was lowered into liquid air so that the mercury froze, the lantern beam could not make the light mill turn; but when the liquid air was removed and replaced by a beaker full of water, enough mercury evaporated to make the vanes of the radiometer spin merrily when the light fell on them. This radiometer, Sir James had ascertained by other means, started when the gas pressure in the bulb was 1/50,000,000 of an atmosphere; the actual pressure reduction attainable by the charcoal must hence be greater still.

In his concluding remarks Sir James Dewar reverted to the actual position of science in the country, with particular reference to the Royal Institution. Germany, he said, had recognised the need of having scientific institutions conducted like the Royal Institution independent both of academic and of industrial control; the five or six Kaiser-Wilhelm Institutes recently founded worked on the model of the Royal Institution, which Haber, the chief of the first of these, had visited for the purpose in 1910. If in England the profession of science were to be conducted on State lines, as it now appeared, the individualistic character of the Royal Institution should all the more be maintained. The Institution relied on the support by its members and had had to struggle. There was the popular fallacy that it was a heavily-endowed body. But the great Royal Institution work of a century (the past) had been carried on at a total expenditure of 120,000*l.*, at the rate of 1,200*l.* a year, therefore. When Sir James had come there, in 1877, as Fullerian Professor of Chemistry, the endowment had amounted to 12,400*l.* Thanks largely to the exertions of their treasurer, Sir James Crichton-Browne, the endowment had now risen to 70,000*l.*; but the membership had gone down to half the pre-war time figure. The Royal Institution had passed through a critical period ten years after the Napoleonic wars; he hoped it would not have to face a similar period again.

TECHNICAL INFORMATION FOR THE AIR FORCE.

On the invitation of the chief officers of Section T5, Royal Air Force, we were present this week at a private view of the Technical Information Centre, which was established in August, 1916, at the School of Military Aeronautics, Reading, but which, due to the expansion and urgent necessity for rapid reproduction of technical data for the Flying Services, was transferred in March, 1917, to its present headquarters in South Kensington. The principal work of the Section is the prompt supply of technical information in the form of:—

1. Notes.
2. Coloured diagrams of the different types of aeroplanes, the aero engines, armament, instruments and details, such as carburettors, oil pumps, systems of lubrication, &c.
3. Rigging diagrams.
4. Lantern slides.
5. Models.

The Section is in charge of technical officers of the Royal Air Force under the direction of Major H. MacCallum, R.A.F., assisted by a staff of experts in the several sub-sections. It was found necessary in order that no delays in the issue of instructions to the aeronautical schools and to the pilots should occur, to not only have a competent staff for the preparation of the technical notes and diagrams required, but to have within the Section means for the production of the pamphlets, the diagrams, the colouring of the diagrams, in fact, to carry out all classes of work which involved the establishment of a printing plant, a lithographic department (including multi-colour printing), a photographic section, and the subsidiary sections to insure the issue of complete instructions with clear diagrams and illustrations in book and pamphlet form.

The work done in the past has been immense, due to the rapid changes and developments which have been constantly taking place, and which must continue to do so in a new and highly scientific branch of modern warfare. The work is necessarily of a very confidential nature; but to give some idea of the extent of the matter to be dealt with we may state that over 110,000 diagrams were distributed during the year 1918, and that the Section is responsible for the distribution of about 3,500 items of technical notes, diagrams, instructions and pictorial illustrations, all of which must be kept up to date, in addition to the preparation of new matter. The total staff at present is about 400, of which about 180 are women.

The most interesting work from an engineering point of view, seen at the time of the visit, was the production of the coloured diagrams and the rigging diagrams. The colour diagrams are prepared under two subheads: (*a*) The "normal," which is an accurate representation of the article to scale; the diagram is coloured to assist the lecturer and to help the novice in following the detail and imprinting it on his mind; the colour system adopted is that in general use on engineering drawings. (*b*) The schematic diagram, for illustrating the principle and not necessarily the actual article. The diagrams are not new, but are superior to those generally used for instructional purposes and, due to their clearness, boldness of line and distinctive colouring, must materially assist instructors and pilots when they are explaining, or are called upon to put into service, a new device.

The rigging diagrams are prepared to illustrate the technical notes on rigging, special care being taken to make them clear and to include all detail of the standing rigging, and for the truing-up of service aeroplanes.

The diagrams are prepared by experts from drawings and models, or during visits to manufacturers' works, and in every case are checked before reproduction by practical men against the actual article. The colouring of the diagrams is done in the case of the first and early issues by the "aerograph," whilst multi-colour lithography is resorted to in the case of the bulk reproduction.

It is necessary that from the educational point of view the important work of preparing the notes and instructions at present carried out by this Section of the Royal Air Force should continue, and arrangements made for the production of the coloured diagrams, which now that the war is over will not be required so promptly, but which are necessary not only for the training of men in the Royal Air Force, the Transport and other services, but for educational purposes at universities, technical colleges and schools. As emphasised in our leading article, the air service is more likely to increase than to decrease now that the war is over, and that military requirements are being replaced by those of peace.

We were informed that centres, modelled upon the Royal Air Force Centre at South Kensington, and upon the experience gained thereat, have been instituted by some of the Allies.

PAYMENT BY RESULTS.

The Watt Anniversary Lecture of the Philosophical Society of Greenock, the native town of James Watt, was instituted to ensure that on the great engineer's natal day there should be an oration dealing with some phase of steam engineering. The task imposed upon the lecturer has become one of great difficulty in successive years, as the whole field of choice of a topic has been covered so adequately by those who have gone before. Thus

in recent years there has been a tendency to direct attention to the economic rather than the purely scientific or technical phase of steam engineering. In other words, the man operating the machine rather than the machine itself has become the main theme, and this year the Watt lecturer, Sir William Rowan Thomson, K.B.E., dealt with some aspects of the labour remuneration problem in the future.

This problem is one which is asserting itself almost every day in connection with industry, and the solution will more readily be found if employers and employed are made fully cognisant of the bonus systems advocated and of their efficacy. As Sir William Rowan Thomson pointed out higher earnings, reduced hours of labour, greater output and reduced labour costs are the demands of the present day industrial situation. It is fully recognised by all economists that these desiderata cannot be achieved by remunerating labour on the time-rate system. The result of that system is, as pointed out by the lecturer, that a man was always tempted to do just as much as would prevent him from being discharged. There is not only a total lack of incentive on the part of the better class of workmen, but slackening on the part of the management. The introduction of piece rates of pay, while it stimulates workmen, has not the same effect necessarily upon the management. The bonus system—where part of the saving goes to reward management—does, on the other hand, produce the effect of stimulating the employer as well as the worker; and every effort put forth by the management is, of necessity, advantageous to the worker, as the week's earnings are increased without augmenting fatigue.

Sir William Rowan Thomson explained both the Halsey or Weir system as well as the Rowan system, contending in favour of the latter. Both systems are good, and the remuneration is equal in the case where 50 per cent. of the time fixed for any job is saved. Beyond this the Rowan system gives a decreased rate to the worker, and for this reason there is less penalty to the employer or industry by any large error in time-fixing. The success of the bonus system is very largely dependent upon the ingenuity, foresight and general efficiency of the management. The lecturer said that any system of payment by results, to be effective and successful, must—(1) operate so as to increase the rate of output, not only without increasing the labour cost, but by actually reducing it; (2) make the reward of the workmen for his share in increasing the rate of output in accordance and commensurate with his exertions in producing such increase; and (3) be capable of quick, easy and safe introduction, and smooth and easy adjustment. He contended that if all the time-workers of this country had been put on payment by results at the beginning of the war, and had saved only one-third of the usual time taken, we should have been able to turn out the same amount of work with two-thirds of the men, or, alternatively, we should have done a larger amount with the same number of men, while the wages earned would have been increased by one-third under the Rowan system and by one-fourth under the Halsey or Weir system. Increased output was a combination of two factors: on the part of the workmen—augmented industry, great dexterity, thoughtfulness, foresight and the wisdom arising from experience, stimulated by an adequate, direct and immediate reward; on the part of the employer—better facilities, tools, power, light, materials and organisation.

THE THEORY OF IONISATION.

When two of the originators of the electrolytic dissociation theory—Professor J. Van't Hoff, then in Amsterdam (later in Berlin), and Professor Wilhelm Ostwald, of Leipzig—came over to the British Association meeting at Leeds in 1890, where they presented papers of quite unpretentious titles, their views met with a very critical reception. Chemists scoffed at the suggestion that the salts of strong acids should split up in their solutions, and that alkali metal ions should migrate unassailed through the water, and Lord Kelvin and Professor G. F. FitzGerald declined to listen to the argument that the solutes of dilute solutions obeyed the gas laws. It was only three years then that the theory of electrolytic dissociation had been proposed by Professor Svante Arrhenius, of Stockholm, and the bold suggestion had not yet found much support. But the ranks of the adherents swelled rapidly, especially among young scientists, over here and in America as well as the Continent. Ions themselves were not a new thing, of course, and they were found to play a very important part in the phenomena of the electric discharge through gases. Soon the old school of chemists was severely shocked further by the phenomena of radioactivity and disintegration of the atom. Moreover, within 20 years scientific opinion had veered so markedly that almost every new book on chemistry and electrochemistry treated matters from the standpoint of the ionisation theory, so-called by preference in order to avoid confusion between ordinary dissociation and electrolytic dissociation. At the same time the difficulties of the theory grew with its quantitative development. Within the last decade the opposition to the theory has strengthened again. It may be because we are approaching the limits of experimental methods and are facing fundamental considerations, when the difficulties of all theories become magnified. But sufficient controversial data have certainly accumulated to make a review of the theory desirable.

The Faraday Society therefore arranged for a general discussion on "the Theory of Ionisation," which was held in the rooms of the Chemical Society on Tuesday last, both in the afternoon at 5 p.m. and at 8 p.m. in the evening after a dinner interval. Sir J. J. Thomson, F.R.S., who was to preside, was unfortunately prevented from coming to London. In his absence Sir Robert Hadfield, Bart., F.R.S., the President of the Faraday Society, took the chair, and was succeeded later in the evening by Professor A. W. Porter, F.R.S., of University College.

Looking back one rather wonders that the theory was not put forward before 1887. Faraday had taught that positive and negative ions, travelling in opposite directions, were the carriers of the electric charges through electrolytes. Kohlrausch had shown in 1876 that the equivalent conductivity of diluted acids, bases and salts, is made up of components due to the anions and the kations. There was the old, forgotten rule of the lowering of the freezing point of water (or other solvents) by dissolving substances in it, observed by Blagden in 1788, and taken up again systematically by Raoult in 1882. Arrhenius and others showed that, whilst an indifferent substance like sugar depresses the freezing point of water to $-1{\cdot}89$ deg. C. (from 0 deg. C.), an electrolyte like potassium chloride causes a depression to $-3{\cdot}5$ deg. C., equimolecular quantities being used, *i.e.*, 1 gramme molecule of substance, as many grammes as the molecular weight of the substance indicates, being dissolved in 1 litre of water. Analogous to this depression of the freezing point was the lowering of the vapour pressure of a solvent by the substance dissolved in it; Von Babo had found in 1848 that the lowering was proportional to the amount of substance dissolved, and here, again, electrolytes showed a greater lowering than indifferent substances.

Further, the osmotic pressure of electrolytes was found to be greater than that of ordinary substances. Now, Van't Hoff ascribed the abnormal depressions and osmotic pressures mentioned to the fact that dissolved substances behave like gas particles. Again, Williamson and Clausius had assumed, as early as 1851 and 1858, that there may be ionisation in solutions owing to kinetic collisions, though that ionisation would probably be small. Putting these facts together, relying in the first instance mainly on the determination of electrolytic conductivity, Arrhenius suggested that the solutions of electrolytes contained not molecules, but dissociated molecules, each dissociated molecule splitting into two separate ions, and that electrolytes gave higher osmotic pressures and depression values, &c., for this reason (additive properties). It was not suggested that the solutions need be completely dissociated, and that the gas laws held for any but diluted solutions. But at extreme dilution the unavoidable impurities of the solvent, salts, or gases (carbon dioxide mainly) in water, substances taken up from the glass vessels, &c., become of enhanced importance. Thus there are great difficulties both with concentrated and with highly diluted solutions. Further, strong electrolytes (strongly dissociated acids or sulphates, chlorides, &c.) differ from weak electrolytes (acetates and organic salts) as to their degrees of ionisation. It sounded strange that just the so-called strongest acids (and bases) like sulphuric acids (alkalis) should yield strongly dissociated solutions, though that objection involved a confusion between activity and affinity. Sulphuric acid is very active or strong; but if it had a strong affinity for its hydrogen, it would not so readily exchange it against metals. In that sense the indifferent hydrocarbons are stronger, as they have a greater affinity for their hydrogen.

In introducing the subject Dr. G. Senter, Principal of Birkbeck College, E.C., drew attention to the difficulties of the theory which were recognised from the first: Strong electrolytes did not follow the law of mass action: the catalytic activity of weak acids was decreased by the addition of neutral salts containing a common ion of the same acid, whilst the activity of strong acids was increased; the mechanism of ionisation was not understood—and is not understood yet. On the other hand there were outstanding achievements of the ionisation theory: Nernst's theory of electro-motive force; the recognition by J. J. Thomson and Nernst (both in 1893) that the ionising power of a solvent is closely connected with the dielectric constant; the investigations of P. Walden (Riga) on the connection between ironising power and other properties of solvents; the work of A. A. Noyes and his American collaborators on the ionisation of strong electrolytes. Dealing first with hydration, Dr. Senter stated that the solvent had first been regarded merely as a medium, but Van der Waals had as early as 1891 suggested that ionisation in water (or in any other solvent) was due to the affinity of the electrolyte for the water (or solvent) and hence essentially a hydration (or solvation) process. It was now agreed that most ions were in aqueous solution associated with water molecules; but the quantitative measurements of the amount of water transported with the ions were very uncertain. As regards the law of mass action the ionisation of strong electrolytes increased more rapidly with increasing concentration than it should according to this law. The C_i^n/C_u, the ratio of the concentration of the ions to the concentration of the non-ionised part, should have a constant value, if the dilution law of Ostwald held $a^2 c/(1-a) = K$, where a was the degree of ionisation, and c the total concentration, the n indicating the valency of the ion; but though the different methods for determining a (conductivity, freezing point, vapour pressure) often gave very concordant results, the dilution law failed for strong electrolytes, whilst holding over very wide ranges in weak electrolytes. In conductivity measurements the viscosity and the value of conductivity at infinite dilution were uncertain factors. The abnormal behaviour of strong electrolytes might be due to the ions, to the non-ionised molecules, and to both, and Noyes, Kraus, Bray, and other American electrochemists, as well as James Walker inclined to the belief that the abnormality was to be attributed to the non-ionised molecules. The suggestion that the ionisation was increased and not diminished by the presence of neutral salts had been disputed by McBain; there was also little to support Sir Joseph Larmor's suggestion, taken up by Partington, that the collisions between the ions and neutral molecules in the solution would facilitate ionisation. The assumptions of complex ions and of an increase in the ionic mobility with increasing ionisation (Jahn and G. N. Lewis) did not appear acceptable either.

As regards chemical activity it had first been asserted that, in the case of electrolytes at any rate, the ions alone entered into the action. That was disputed by Dr. Senter himself, by Acree (whose paper we are going to mention) and others, and the further suggestion that in catalytic reactions of acids in particular, the hydrogen ion alone was the active constituent was no longer sustained by Arrhenius himself; neutral salts, it was now generally conceded, also played a part.

We now pass to a brief review of the many communications discussed at the meeting under notice.

Professor Svante Arrhenius had sent a communication on "Electrolytic Dissociation," and was possibly a little over-zealous in his introductory remarks on the evidence in favour of the theory. He spoke of the chlorine test—precipitation of silver from nitrate solution—as having been considered as characteristic for all chlorine compounds. But it was fully recognised long before the days of the dissociation theory that the reaction was not a general test for chlorine, but only for chlorides, and that it failed in the case of chlorates and of organic chlorine compounds. What the theory did was to show that, wherever the test succeeded there was also other evidence for the assumption of chlorine ions. Similarly it was quite understood that, in precipitating a barium salt with sulphuric acid or a sulphate, an excess of acid or of sulphate was desirable as it lowered the (very slight) solubility of the barium sulphate to be precipitated; on the new theory it was said that the greater the quantity of sulphate ions, the smaller the quantity of barium ions in the equilibrium; that however, was no more a real explanation than the mentioned change of solubility. The claims that only ions reacted, and that undissociated compounds could not enter into chemical reactions, also went too far. The colour argument is also disputable, as Arrhenius acknowledged; all solutions containing one uncoloured ion and one common coloured ion, *e.g.*, all permanganates, should have the same colour in any uncoloured solvent; that had been extended to all indicators (substances which mark the end of a reaction by colour changes), but isomerism may complicate these phenomena. But the additive properties above alluded to were very strong arguments in favour of the theory. Arrhenius further mentioned the fact that the diffusion of HCl in water is hastened by the presence of chlorides like NH_4Cl or NaCl, which is difficult to understand if the H and Cl be bound together, though his own explanation is not easy to grasp either.

What had led Arrhenius first to his dissociation theory was the consideration of conductivity data. In his dissertation of 1884 he considered electrolytes to consist of conductivity and of non-conductivity molecules in such equilibrium that with extreme dilution all the molecules became conducting—dissociated as he proposed in 1887—whilst with increasing concentration the non-conducting molecules increased at the cost of the condensing ones; the degree of dissociation would be $a = \lambda_v / \lambda_\infty$, where λ_v indicates the molecular conductivity for 1 gram-molecule in v litres, and λ_∞ the conductivity at infinite dilution. This first dilution law was modified by Ostwald and others; later dissociations were determined from solubilities, but this method did not prove, as Arrhenius showed, any more in accord with the law of mass action than conductivity measurements. The many-sided researches by Professor Arrhenius on reaction velocity, concerning also physiological chemistry, further support his theory. In his communication he did not fail to dwell also on the difficulties of the theory.

A paper by Dr. James W. McBain, of Bristol, and the late Mr. F. C. Coleman (killed in action), on "The Bearing of Migration Data on Conduction in Solutions and on the Electrochemistry of Sodium Iodide in Acetone," was submitted. The authors started from six hypothesis, three due to Walden: (1) increase in ionising power of the solution with increasing concentration; (2) increased ionisation of the solvent for the same reason; (3) change of the dielectric constant of the solution with increasing concentration of the solvent; and three due to others: (4) change of the ionic velocity with concentration; (5) that a Grotthuss conductivity be superposed on the normal ionic and activity; (6) that the solvent also conducts. The evidence presented by Captain McBain seemed to negative (1), (2) (6), he said; Kraus and Bray had disproved (5); and (4) was of questionable value because conductivity measurements could not reveal the true degree of dissociation.

The problems Professor McBain discussed involve the question: does the solvent in a solution conduct? and thus the distinction between solvent and solute which is not always clear. Both water and hydrochloric acid are insulators in the pure state, but mixtures of the two conduct, and seem hence mutually to dissociate one another. Hittorf tried to answer the question as early as 1856 by comparing the migration data with Faraday's electrolytic law. If the movements of the copper and of the sulphate in a solution of copper sulphate together come up to the one gramme equivalent per coulomb, then the current must be carried by these ions only, and the ions of water, if there be any, have no part in the conductance. Complete migration measurements have, however, hardly been carried out; they require the separate determination of the migrations of both the ions and full analysis, before and after the electrolysis, of all the constituents concerned. It has so far been assumed that water is dissociated to a very slight extent; but pure "conductivity water" is very difficult to experiment with. Acids, ammonia, amines, SO_2, alcohols, &c., themselves non-conductors, show peculiarities when dissolved in one another or in water; the conductivity may increase or decrease with dilution or may display maxima. Which is the solvent in each case, and whether it conducts is not easy to decide. Professor McBain hence carried out what is probably the first complete set of migration measurements described, experimenting in vessels built up chiefly of borosilicate glass and platinum with solutions of sodium iodide in acetone and also with silver bromate, a typical colloidal electrolyte, in dimethylamine. He found that the solvent did not conduct appreciably, and that conductivity could only be a rough measure of the degree of dissociation, because the migration ratio (anion/kation) increased with the concentration. He, therefore, concluded that the various empirical dilution laws are all arbitrary and devoid of theoretical basis. This was the most direct attack on the theory made during the discussion, and it did not find support.

(To be continued.)

SOUTHAMPTON TRAIN FERRY.

THE need of some means of transit to the Continent for heavy and unwieldy goods has been felt for many years, and before the war the much-discussed Channel Tunnel scheme seemed to embody the most efficient method of supplying that need.

When war broke out, the need soon developed into an urgent necessity, and one so immediate that the inherently long process of boring a tunnel was quite out of the question. The only other solution was a train ferry, and early in 1917 a scheme was approved by the War Cabinet by which two services of ferries were to be instituted between the South Coast of England and the North Coast of France. The two ports in this country were to be Southampton and Richborough, and the two corresponding ports in France were Dieppe and Calais. No work of this kind had previously been attempted on a scale in any way approaching that of the present scheme, so that the fact that the ferries have worked without a hitch, from the day they were opened a year ago up to the present time, is a very great tribute to the efficiency and ability of the Department of Inland Waterways and Docks, Royal Engineers, by whom the work was undertaken. The whole of the mechanical part of the scheme was placed in the hands of the well-known firm of Sir W. G. Armstrong, Whitworth and Co., and military labour was used throughout, both on the railways, which link up the ferries with the inland systems, also on the erection of the bridges, and the berths themselves.

In December, 1917, all the arrangements at Southampton were complete, and during that month the first train was shunted across the adjustable bridge on to the deck of the ferry, and shipped over to France. It is in the transit of heavy and bulky goods that the enormous saving of time and labour is most evident; locomotives put on rail in the erecting shops in England can be run straight over to any part of France, a new tank can crawl into a wagon at the works under its own power and crawl off again a few miles from the firing line. A large-calibre gun can be put on rail in the shops and dropped alongside its emplacement. Again, when it is considered that the ferry can be brought alongside, tied up, take aboard a goods train of 64 trucks, and be at sea again in under half an hour, it can be seen what an enormous development in Continental goods traffic this ferry will mean in the future. Apart from the design of the ferry as a sea-going ship, the chief interest in the design centres in the provision which has to be made, firstly, for adjusting the bridge forming the rail end, so as to allow for all conditions of tide and ferry load, and secondly, for keeping the ferry trimmed both while the trucks are being shunted and after the load is aboard. The necessity of allowing for the tide is obvious, and the maintenance of a perfect trim during loading is equally important, as it is clearly most undesirable that there should be any great constraint by the bridge on the ferry, and *vice versa*, when the two are locked together.

It is also obvious that the terminal ports of a train ferry should be easy of entry in all weathers and at all states of the tide. Southampton, of course, is ideal in these respects, and it was this consideration, in conjunction with the fact that the town is a most accessible railway centre, that far outweighed the drawback of the comparatively long sea passage to Dieppe, and led to the port being chosen for the work. Up to the present three vessels have been engaged in the service, and in 1918, over 18,000 railway trucks were transported across the Channel, and over 290,000 tons gross of war material was carried.

The Southampton scheme was started on March 3, 1917, by laying a temporary single-line railway along the whole length of the Western Esplanade, connecting with the main line of the London and South-Western Railway at Southampton West Station at the west end, and with the Dock Station line opposite the Royal Pier at the east end. This line was employed for the conveyance of the whole of construction plant, materials, &c., used on the works, including 140,000 tons of stone debris and 85,000 tons of ballast.

We began the publication of drawings illustrative of this interesting work by giving last week a two-page plate containing reproductions of photographs of one of the ferry steamers, while this week we publish Plates VII and VIII, giving detailed sections and plans of these train ferries.

These train ferry steamers had to fulfil unusually difficult conditions and therefore are interesting specimens of naval architecture. The physical characteristics of one of the terminal ports in this country made shallow draught a *sine qua non*, and as it was considered that the volume of traffic would be so large as to entail at least four railway tracks on the vessels, the limiting conditions of the design were very clearly defined. The principal dimensions which were eventually decided upon were:—

	Ft.	In.
Length over all	363	0
Length between perpendiculars ...	350	0
Breadth extreme over feniers ...	61	6
Breadth moulded	58	6
Depth moulded	17	0

The displacement of the vessels was 3,775 tons on a mean draught of 9 ft. 6 in., and the speed under these conditions was to be at least 12 knots. On trials, with the vessel fully loaded, the speed attained was 13¼ knots.

As no passenger trains were to be carried, it was considered unnecessary to house the railway deck, and this, therefore, became the weather deck of the ship, with the exception of the small portion forward. The forecastle was thus utilised for the accommodation of the crew and petty officers, and all the rest of the accommodation was arranged below the railway deck, as it was found impossible to combine a sufficient width of sidehouse with the space required for the four railway lines on the largest area of deck which other considerations permitted.

The longitudinal strength of the vessel required, of course, very careful consideration; the moulded depth of the railway deck had to be kept as small as possible, and yet provision had to be made for very heavy rolling loads. The method by which these problems were solved is shown on the drawings. A bridge is fitted amidships (Fig. 7), with captain's room, chart-room, accommodation for the

wireless operators, and a wireless room and wheel-house above.

Powerful capstans are fitted forward and aft for handling the railway traffic if occasion requires, but as it was found in practice that the operations of loading and discharging could be efficiently carried out by means of locomotives, the special capstans have seldom been found necessary.

The sea-going qualities of the vessels have proved to be sufficiently satisfactory, and they have carried on their service without intermission, except when navigation was prevented by fog. Special arrangements were made for securing the rolling-stock to the railway deck in heavy weather, but in practice it has been found that they were almost unnecessary, and that the loads could be satisfactorily carried without them. Wooden runways were provided on the railway deck alongside the rails, for the carriage of motor lorries, and these have proved a very valuable addition to the service for which they were originally intended.

The vessels were designed by Sir W. G. Armstrong, Whitworth and Co., Limited, who built two of them in their own shipyards, and the third was built and engined by the Fairfield Shipbuilding and Engineering Company.

The machinery for the vessels built by Messrs. Armstrong was constructed and fitted on board by the Wallsend Slipway and Engineering Company, Limited. The propelling machinery consists of two sets of three-crank vertical triple-expansion engines driving twin-screw propellers. Owing to considerations of draught of water and construction of the hull it was found necessary to run the propellers at a somewhat higher number of revolutions than customary with three crank engines, so that in order to reduce vibration to a minimum balance weights have been fitted to the cranks. As the particular service for which these vessels are intended calls for hard driving and rapid manœuvring, involving heavy loads on the framing and bearing surfaces of the working parts, the whole engine structure has been designed towards that end. The cylinders, consisting of high, intermediate and low pressure, are respectively 18 in., 29 in. and 47 in. diameter, with a common stroke of 27 in. The high-pressure cylinder is fitted with a cast-iron liner. The pistons are all made of cast steel, with a view to providing the greatest strength with the minimum weight. Each cylinder is carried on two cast-iron columns of box form. Guide bars fitted with water service are fitted for both ahead and astern-going motions, the guide bars being bolted to the columns. The bedplate is of cast-iron of box form and specially strong design, two bearings for each cylinder being provided and the crankshaft is of the built type. The whole of the shafting and other large forgings are of ingot steel. The thrust block is made on the adjustable horseshoe principle, the shoes having internal water service. The propellers are of the solid-type cast in bronze.

The high and intermediate cylinders have piston slide valves, while that of the low-pressure cylinder is of the flat type. The valve gear is of the usual double eccentric and link-motion type. To provide for rapid manœuvring, the reversing gear is operated by a direct-acting engine of the hydro-steam type, and the valve for steam admission to the high pressure is of the double-beat type, worked by a hand lever. In addition, the usual starting valves are fitted.

The condensing plant is entirely independent of the main engines, and no pumps are worked off the engines. A single condenser is provided, and this is placed between the two sets of engines, which are much wider apart than usual. The condenser is of the Weir's "Uniflex" type, and is built up of steel plates. The plant is capable of maintaining a vacuum of 25 in., with a barometer of 30 in., and circulating water at a temperature of 65 deg., when the machinery is developing its full power. Two air pumps are provided, placed in close proximity to the condenser. These pumps are of the single-cylinder direct-acting monotype design; they are of the merchant-service type, having gun-metal barrels with cast-iron bases and tops, fitted with gun-metal buckets and manganese pump rods. One centrifugal pump is supplied for circulating water through the condenser. The pump is driven by two single-cylinder enclosed forced lubrication engines. Each of the two engines is to be capable of doing the whole of the work, while one remains as a standby.

The main feed pumps consist of one pair of direct-acting vertical pumps, each pump being capable of delivering the necessary feed water when the machinery is developing its full power. Working in conjunction with these pumps is a "Cascade" filter, which is fitted with control gear for regulating the speed of the feed pumps. A live steam feed-water heater is placed in the main line of feed delivery pipes to the boilers.

In addition to the above auxiliaries, there are installed on board an auxiliary feed pump, one fire and bilge pump, together with two ballast pumps, each of which is capable of delivering 300 tons of water per hour. All these pumps are of the vertical duplex type.

The boilers which have also been supplied by the Wallsend Slipway and Engineering Company, are four in number, of the usual marine multitubular type, single-ended. They are 12 ft. 6 in. diameter by 11 ft. 9 in. long, and have been constructed for a working pressure of 180 lb. per square inch. The boilers are arranged for burning liquid fuel in conjunction with Howden's system of forced draught. For supplying the necessary air for the system two fans are supplied. These fans are of the double-inlet type, each driven by a single-cylinder enclosed forced lubrication type engine. The installation for burning liquid fuel is arranged on the pressure principle, and is in accordance with the Wallsend-Howden usual practice. The furnace fronts are modified somewhat in construction to suit the burning of liquid fuel, and are each fitted with a patent burner. The pumping and heating plant is comprised of two similar sets, each set consisting of one horizontal simplex oil fuel pump with air vessel, one heater with relief valve, one water collector, one duplex discharge strainer, including pressure gauges and drain cocks, all erected on an oiltight tray. Each of these sets is arranged so that it can draw from the oil fuel supply tanks through a duplex suction strainer and deliver through the duplex delivery strainer and heater to the burners. Either of these pumping and heating sets is capable of dealing with the total quantity of oil required for all the boilers, one unit remaining as a standby in case the working set requires overhauling. Auxiliary steam-raising apparatus is supplied and fitted in conjunction with this there is a two-throw hand pump, for use when raising steam.

The boilers are placed in the extreme wings of the vessel, two boilers at either side, each boiler with its own stokehold arranged fore and aft. Two chimneys are provided, one at either side, fitted with air casing, and cape above the deck. The section of the chimneys, together with the boiler-room deck casings, are designed with a view to providing the maximum of deck space in an athwartship direction. The machinery generally was constructed to Lloyd's Rules and Regulations, with departures where essential to conform with certain limited Admiralty requirements.

(To be continued.)

THE GERMAN ELECTRICAL INDUSTRY.—So far the German electrical industry seems to have done well, and the balance sheets of the Siemens and Halske and the Siemens-Schuckert concerns for last year show no alterations of importance, compared with the previous year. Inclusive of the sum carried forward from the preced ng year the working profits of Siemens and Halske for last year amounted to 17,750,819 marks, against 17,912,893 marks for the previous year, the surplus interest, writings-off, &c., having been deducted, amounting to 13,954,781 marks against 12,875,262 marks for the previous year. The dividend was again fixed at 12 per cent., a sum of 3,000,000 marks was set apart for aiding the staff for the year 1917-18, and 1,600,000 marks (against 1,200,000 marks for the previous year) to gratuities to the staff and operatives. The Siemens-Schuckert concern had working profits for last year amounting to 26,940,716 marks, inclusive of balance carried forward, against 26,507,919 marks for the previous year. After deducting interest, &c., there remained a surplus of 15,837,800 marks, against 15,878,765 marks for the previous year. A dividend of 10 per cent., the same as the previous year, was paid; 2,500,000 marks, as for the previous year, were added to the reserve, and 500,000 marks, as for the previous year, to the fund "at disposal."

LITERATURE.

The Six-Hour Day and Other Industrial Questions. By Lord LEVERHULME. With an Introduction by Viscount HALDANE OF CLOAN. Edited by STANLEY UNWIN. London: George Allen and Unwin, Limited. [Price 12s. 6d. net.]

THIS is a fascinating book, and it appears most opportunely. The author is an optimist who believes in his fellow man, whether he be capitalist or workman, and desires to see him prosperous and happy. If his ideas should be widely absorbed and acted upon the future will be very different from the past. The capitalist will be relieved from a load of anxiety and worry, and the labourer will be a willing worker with ample leisure and education facilities to enable him to utilise it in securing a wider and a happier life. Class antagonism will be mitigated, and intelligent self-interest will take the place of suspicion, hatred and distrust. This sounds like a fairy tale, but Lord Leverhulme is no romancer. He has been brought up in a hard school, and although it has not soured him, yet it has taught him the immutability of economic laws. He scorns the name of philanthropist, and repudiates the idea of sacrificing his interests as a capitalist and manufacturer to those of labour. His panacea for the ills of the world is efficiency, and more efficiency, and still more efficiency. In this he only preaches what he has practised all his life. It is common knowledge that he started at the foot of the ladder, and that by ability and industry he has built up an immense business and gained great wealth. There is a popular idea that soap makers are always rich, but it is far from the truth. There are plenty of soap factories that make little or no profits, and among those which are successful there has always been keen competition. It is only in those which have been efficiently managed that success is attained, and foremost among these is the great works at Port Sunlight. In every department of the works, and also in the vast buying and selling organisation spread over the entire globe, efficiency is constantly cultivated, and the search for newer and better methods is never relaxed. The whole is a monument to Lord Leverhulme's personal efficiency and to his influence in inspiring others.

We have had efficiency preached during the past months until we are sick of it. Journals have been started to explain it, and specialists have advertised their services for managing other people's business and making fortunes for them. One feels inclined to class them with the tipsters who tell the public on what horse they should put their money, and yet are always out-at-elbows themselves. There is nothing of that kind in the book before us. Lord Leverhulme does not explain how efficiency is to be attained, all that he does is to insist that it is the key, and the only key to prosperity. He shows that mankind can only have what it earns, and that no juggling with wages and hours of labour will bring ease or comfort unless it is associated either with greater effort, or better directed effort. If output is lessened some must go short, and it is usually the working classes who suffer most. If wages are increased without greater productivity prices will rise, and the wage earner will be no better off. Conscription of wealth cannot be confined to the rich, for its effects will spread through all classes and the poor will be the least able to bear them. The author insists again and again that the laws of economics are as rigid as the laws of physics, and that it would be as easy to produce perpetual motion as to provide for a community that will not work.

This seems a discouraging prologue to a project for reducing the daily hours of labour to six. It is true that in the past, hours have been reduced from 14 to 12, from 12 to 10, and sometimes even to 8 without detriment to the output. In the earlier instances human nature responded to the better conditions and automatically put forth greater effort. The workers were less exhausted at the end of the day; they slept a more refreshing sleep, and came to work more alert. In the latter instance the management exerted themselves to attain greater efficiency. In coal mines underground roads were widened, larger tubs were provided, and quicker winding attempted. In workshops and factories

better methods were adopted and more efficient machinery was installed, and by that means the output was generally maintained, although greater capital expenditure was often involved. But every engineer knows that each succeeding step or stage in efficiency presents greater difficulty. The history of the heat engine affords an example of this. The same is true also of human efficiency; for long there has been a determined attempt at speeding-up in workshops, and this to a certain extent has been successful, the margin for possible acceleration being now much less than it was. But a diminution of hours from eight to six is relatively a larger step than has ever yet been made, and it can only be contemplated if capitalist and worker are alike fully determined to put forth their best efforts. On the one hand it is scarcely possible that an average workman can permanently increase his hourly output by 33 per cent., while on the other hand if the capitalist is to instal new and better machinery on a large scale his overhead charges may easily eat up all the economies. Only by cordial co-operation between master and man, each doing his fair share, can a 33 per cent. increase in efficiency be attained in the immediate future.

Lord Leverhulme does not suggest that the six-hour system is of universal application. On the contrary he lays it down that it is only applicable to businesses in which the overhead charges are at least equal to the wages, and he implies, if he does not state it, that at least two shifts must be worked. In the overhead charges he appears to include interest at 5 per cent. on the capital, profits being only reckoned after this. He makes no reference to such matters as coal, oil and water, costs of which increase with the hours worked, and which in such a computation should be reckoned with wages. Neglecting, however, such matters, the conditions under which a six-hours' day, with two shifts, is feasible are to be found only in a business in which the capital value of the plant is fairly large, and the cost of management considerable. Clearly, if a plant works 12 hours a day instead of eight, interest and obsolescence on each unit produced will be reduced by one-third, while very probably the cost of management per unit will decrease although not quite in the same ratio. At the same time, 16 hours' wages will have been paid for 12 hours' work, and if the rate of output has not increased the wages cost per unit will have gone up 33 per cent. The result is that the total cost per unit is unchanged. If the on-cost charges are less than the wages, then the cost per unit will be increased beyond the former scale.

Lord Leverhulme would scarcely have publicly advocated a six-hours' day if he had thought that it would entail a 33 per cent. increase in the wages cost of the work turned out. He knows that there are few works in which an increase of efficiency cannot be attained both by the management and by the workers. The past four years have shown what vast improvements can be made in shop operations when necessity obliges, while the output of women munitioners is clear evidence that there previously existed a restriction of output. Perfection, like happiness, always glides ahead of us, just out of reach, and there is no reason to believe that we have attained the final result in workshop economics even in the simple matter of making shells.

If it be conceded that by the joint efforts of workers and managers it is possible to produce in certain heavily capitalised industries as much in six hours as was formerly done in eight or nine, it remains to be considered whether it is desirable. Lord Leverhulme seems to doubt whether it is, just now, for he speaks rather of the future than of the present. He insists on the need of better education for the masses, of wider interests, and more comfortable homes. All these are needed for the proper utilisation of more leisure. A six-hour day, starting at eight o'clock would, with a break of half an hour at noon, end at 2.30, and would raise the question—What was to be done with the remaining hours? In summer many would find a resource in gardening, cricket or country walks. But the summer is short-lived, and often in this country it does not answer to its description. Further, there are many men who take no delight in out-of-door pursuits and who cannot amuse or interest themselves in books. As for the winter, even the bulk of the well-educated and well-to-do would find it difficult to occupy themselves agreeably every afternoon, or every morning, as the case might be. Books, music, golf and gossip would scarcely fill the whole time, even with a well-appointed home in the background. If the six-hour day could be from 10 to 4, or 5, then the case would be simpler and the worker would be much in the position of the civil servant of a past age. But with two shifts at least, and possibly three, such hours would be impossible, and each man would find himself with several consecutive hours of daylight in which he had no work and very little amusement.

Lord Leverhulme, of course, has not overlooked the difficulty, and he has a project of devoting—compulsorily we rather gather—several hours each week to secondary education and to physical and military drill, the course extending until a worker reaches the age of 30. Of course, such a system could only be carried through if it attained the hearty goodwill of the workers, and at present there is very little evidence of a general willingness to submit to such discipline.

We have confined our remarks so far to the leading feature in the title of the book, but this really only occupies a minor portion of the volume. The "other industrial questions" such as co-partnership, housing and social welfare, education and business, are treated at much greater length and with considerable iteration. In the main the book consists of reports or reprints of addresses delivered before all kinds of societies and bodies, varying from Chambers of Commerce to P.S.A.'s. The majority of them deal with the author's attempts to enlist the interest of his workpeople in the success of his business, and the fact that he was many years in evolving a satisfactory scheme is evidence of the difficulty of the problem. The existing method is termed by him co-partnership, and appears to be working well, as 487,353*l.* have been distributed in nine years. We must refer our readers to the book itself for the details, but lest they should be too sanguine we may explain that the workers do not begin to share until the capital has received 5 per cent. A scrutiny of the records of engineering limited companies would show that such condition of co-partnership would yield barren results in the case of many of them.

Whether the reader agrees with Lord Leverhulme's methods and projects or not he cannot fail to derive both pleasure and profit from the perusal of the book. It will raise his courage to confront the many problems before us, and will fill him with hope that after a period of very serious commotion and unrest we shall attain to more stable and more satisfactory conditions. It will strengthen his belief in the inherent sanity of human nature, or at any rate, of British nature, and it will save him from the pitfalls dug by those who imagine that good intentions necessarily lead to good results. It may be that after being carried on by the author's breezy optimism, he may find doubts arise on reflection, but nevertheless it is impossible to ignore the fact that a man who has "made good" in a most remarkable way and has the most complete knowledge of business, still has full confidence in the relations of capital and labour, and in the future of the British nation.

Unfortunately many will quote the book without having read it. They will state that Lord Leverhulme has published, as his considered opinion, that six hours constitutes a satisfactory working day, and that capitalists can make ample profits under such an arrangement. Of course, he says nothing of the kind. His advocacy of a six-hour day is hedged round with conditions, and these involve much expenditure for the capitalist, great thought and effort for the management, and whole-hearted diligence for labour. If any one of the three fails to bring his contribution to the solution of the problem the desired result cannot be achieved; and even if all make the effort with true loyalty, it is only in certain trades and manufactures that success can be expected. For the present the six-hour day must remain an ideal toward which we may work, but which is not of immediate attainment. Education must be much wider and deeper before it will be really advantageous for the working-classes, or, indeed, for any class, for there is no great body of men in this country who have the mental equipment to occupy profitably such ample leisure. The old saw about mischief and idle hands is as true now as it was in the days of Dr. Watts.

OUTPUT AND STOCKS OF IRON AND STEEL.

THE following figures are issued by the Minister of Munitions:—

A. *Stocks of Iron and Steel.*—The total stocks in the hands of the Government available for disposal at the end of December, 1918, were as follows: Pig-iron (Swedish), 80,000 tons; shell steel billets (suitable for re-rolling), 210,000 tons; ship plates (purchased in U.S.A.), 19,800 tons; bright steel, 5,000 tons; bar iron (Swedish), 10,000 tons.

These figures, which include all stocks of U.S.A. steel in this country, only represent stocks in the hands of the Government still to be disposed of, and do not include stocks in the hands of private firms; neither do they include stocks of forgings and semi-finished shell.

B. *Outstanding Commitments from Overseas.*—The bulk of the Government contracts in U.S.A. for iron and steel have been cancelled, and the existing stocks of shell steel at American ports and steel works are being disposed of in the American market. The only outstanding commitments still due to arrive in this country are: (1) 20,000 tons of basic pig-iron from U.S.A., the whole of which has already been allocated to its final destination; (2) 7,500 tons of wire rods from U.S.A. and 2,500 tons from Canada; and (3) 4,000 tons of pig-iron from Sweden.

C. *Output.*—The average weekly output of pig-iron and steel ingots and castings in the United Kingdom during the last six years is as follows:—

	Pig-Iron.	Steel (Ingots and Castings).
1912	168,000	131,000
1913	200,000	147,000
1914	173,000	151,000
1915	169,000	161,000
1916	174,000	173,000
1917	179,000	187,000
1918	175,000	184,000

Output during the latter half of 1918 was seriously interfered with by the influenza epidemic in July and the armistice in November. The average weekly output figures for the first half of the year were 181,000 tons of pig-iron and 192,000 tons of steel.

Actual weekly figures of output for the months October to December, 1918, are given below:—

Pig-Iron.

	Tons.
Week ending October 5	176,000
" " " 12	167,000
" " " 19	180,000
" " " 26	183,000
" " November 2	180,000
Average for October, 177,000 tons per week.	
Week ending November 9... ...	178,000
" " " 16... ...	136,000
" " " 23... ...	165,000
" " " 30... ...	170,000
Average for November, 162,000 tons per week.	
Week ending December 7	167,000
" " " 14	168,000
" " " 21	156,000
" " " 28	136,000
Average for December, 157,000 tons per week.	

Steel (Ingots and Castings).

	Tons.
Week ending October 5	206,000
" " " 12	203,000
" " " 19	208,000
" " " 26	207,000
" " November 2	204,000
Average for October, 205,000 tons per week.	
Week ending November 9... ...	197,000
" " " 16... ...	72,000
" " " 23... ...	148,000
" " " 30... ...	178,000
Average for November, 149,000 tons per week.	
Week ending December 7	186,000
" " " 14	188,000
" " " 21	185,000
" " " 28	82,000
Average for December, 127,000 tons per week.	

THE BERNITS BOILER FURNACE.—In order to prevent the formation of clinkers on the side and bridge walls of boiler furnaces, a method of construction has been devised by the Bernits Method Company, Tremont Building, Boston, Mass. It is illustrated and described in the journal *Power*, New York, and consists of an arrangement of firebrick in the furnace walls, whereby air is admitted into the fuel bed, between the bricks of the side setting or at the bridge wall. By supplying forced draught through these air passages, the face of the brick in the furnace wall is kept comparatively cool, the idea being that the clinker will not then adhere to the brick surface. Combustion at these points is stimulated and increased.

DESIRABLE DEVELOPMENTS IN ENGINEERING INDUSTRIES.

THE Engineering Trades (New Industries) Committee of the Ministry of Reconstruction have submitted their report, and the following article on the subject is sent to us officially :—

The committee were appointed by Dr. Addison in December, 1917, to compile a list of articles (suitable for manufacture by those with engineering trade experience or plant), which were either not made in the United Kingdom before the war, but were imported, or were made in the United Kingdom in insufficient quantities, and for which there is likely to be a considerable demand after the war. The committee consisted of 16 leading engineers and manufacturers, under the chairmanship of the Hon. H. D. McLaren, C.B.E., M.P., but with it was a labour panel of 11 leading trade unionists, under Sir Claud Schuster, to advise on labour questions likely to arise in the setting up of new industries.

A list of imported articles having been compiled, the committee found that the best way of proceeding was to set up a number of Branch Committees, each of which could give detailed consideration to a particular group of articles in the list. These committees were 15 in number and dealt respectively with : (1) Agricultural Machinery ; (2) Holloware, Sheet Metal and Pressed Work ; (3) Electrical Plant ; (4) Machine Tools ; (5) Miscellaneous Machinery ; (6) Scientific Apparatus ; (7) Textile Machinery (subdivided into eight Branch Committees) ; (8) Light-section Rolling and Extension ; (9) Wire Drawing Machinery ; (10) Printing Machinery ; (11) Printers' General Machinery ; (12) Paper-making Machinery ; 13) Leather-making Machinery ; (14) Aircraft ; (15) Motor Industry. Each committee consisted of expert members drawn from the industries appropriate to its group, but was presided over by a member of the Main Committee. In this way the knowledge and services of some 150 leading manufacturers of the country were drawn upon. The committees also worked in close touch with their industries as a whole. From certain industries not represented directly in the 15 groups, special evidence, supplied in reports or by witnesses, was taken. In the case of certain articles on the list it was found desirable to undertake experiments before reporting on the possibility of manufacture. For these, materials and other facilities were obtained through the Ministry of Reconstruction.

The report now issued consists of a report by the Main Committee as a whole and reports from each Branch Committee, dealing with a particular group of manufactures. The Main Committee make certain general observations as to the conditions under which new industries should be set up if they are to develop successfully, touching upon such questions as finance for industry, export trade, foreign competition, the improved methods necessary if British engineers are to maintain a leading position, industrial and scientific research, exhibitions, education and labour conditions. The committee strongly recommend the more extensive adoption of specialisation and standardisation, particularly in the case of small manufacturers who, in their opinion, would do better to confine themselves to the manufacture of a few types of articles which they could then bring to greater perfection and produce more cheaply. The committee think that such a concentration by each manufacturer on a few types of articles, with proper standardisation would enable engineering operations to be carried out as "repetition work." This would not only enable many men, highly skilled and highly paid, to be employed in manufacturing the necessary tools and jigs, but would also create an opening for the employment, at good wages, of a number of unskilled and semi-skilled operatives, both male and female, and wounded soldiers. In this connection the committee emphasise the importance of co-ordinating manufacture and design, recommending that in future all Government designs and specifications should be considered in co-operation with experts in workshop methods of production. They are of opinion that in the absence of special circumstances Government departments and public authorities should order standard goods of British manufacture, and that in cases where there is no question of ordering standard design they should have in view the encouragement of the production of articles of new and improved types or of experimental design.

In order to stimulate production the committee consider that employers and workpeople alike should be educated both generally and specially—employers and staff, in regard to what is being done in up-to-date works, where quantity production under scientific management is carried on ; and workpeople, to remove the impression that quantity production produces unemployment, and to make them realise the national importance of producing the maximum output in the minimum time. The committee concur in a number of conclusions drawn by the Labour Advisory Panel, and recommend that new industry should not be introduced into this country unless the wages paid to those employed in it are such as to ensure an adequate standard of living and unless machinery exists or can be set up for regulating rates of wages and hours of labour ; further, that no industry be introduced under conditions involving any special liability on the part of those engaged in it to industrial disease. Incidentally, light is thrown upon the restrictive effects of legislation in the past upon the development of British industries, and upon other conditions, such as the incidence of taxation, dumping, &c., which, in the opinion of those engaged in engineering, stand in need of reform.

The report then gives summaries of the reports presented by the various Branch Committees. In view of the newly recognised importance of agriculture in this country, the report of the Branch Committee on Agricultural Machinery will be of interest. While they consider that this industry was on the whole in a fairly satisfactory condition before the war, they think that there is room for considerable development, both in home and export trade. They draw special notice to the motor tractor industry, which is more highly developed in the United States than in this country. Several British firms were devoting attention to this production before the war, but Government demands upon them for munitions greatly retarded the development of this industry. The result of the importations by the Government and private firms of American tractors on an immense scale is watched with some anxiety. Many firms are preparing to manufacture them, and they will be produced here in large quantities as soon as the necessary raw materials and labour are available. In view, however, of the advantageous start given to the imported article, due largely to Government action, it is very important that every facility and encouragement should be given to British makers at the earliest possible moment. Amongst other agricultural articles, the manufacture of which could in the committee's opinion be greatly developed, are cream separators, swath turners, hay loaders, disc harrows, and corn and seed drills.

The Branch Committee on Holloware, Sheet Metal and Pressed Work, in a detailed report on 65 branches of manufacture, consider that only a small percentage of highly-skilled labour is required in this branch of industry, mainly for tool-making and repairing. Of the remaining labour, having regard to the amount of physical strength and mechanical aptitude required, women to the extent of about 50 per cent. could be employed. Among the many articles dealt with by this committee are sewing machines and typewriters. Large firms are known to be taking up the manufacture of the former, and it is believed that these will be adequately manufactured in this country, but there is room for considerable development in the manufacture of typewriters.

Interest also attaches to the report of the Branch Committee on Electrical Apparatus and Machinery, who consider that as regards most of the articles under their consideration ample manufacturing facilities exist, and in many cases did exist before the war, for meeting the whole requirements of the United Kingdom and Colonies and, in certain cases, for meeting the export trade to other countries, but that these facilities were not fully employed owing to the importation of articles from abroad. They lay special stress upon the necessity for ensuring the continuance of the manufacture of carbons, and attach a special report as an appendix which points out that had it not been for the action of one firm in continuing to make arc-lamp carbons at very considerable loss to themselves, the country would have had considerable difficulty in meeting the demands for search-light carbons. With regard to magnetos, now adequately made in this country, the committee recommend that German magnetos should be excluded for a period after the war, except under licence, and that a duty should be imposed on all imported magnetos.

The Branch Committee on Scientific Apparatus point out that the scientific apparatus industries are vital to the nation during peace and war. No country can remain for long in the front rank industrially if it depends upon others for its scientific apparatus, because such apparatus is generally produced where science is most actively applied in industry. The committee gives a long list of articles which are not adequately manufactured in this country, and in regard to which there is room for new industries. One such industry is the manufacture of clocks and watches on a large scale. They consider the establishment of such an industry of very considerable importance. In Switzerland, Germany and the United States, these manufactures, turned out in large quantities and cheaply, constitute the chief training ground for skilled mechanics accustomed to work of the highest precision and finish. In this country, which has no such training ground, the scientific apparatus industry suffers from lack of such skilled help and manufacturing experience.

The Branch Committee on Aircraft Machinery consider that owing to the enormous expansion of the industry during the war, its output capacity will be greater than the demand for years to come, and advise that immediate steps should be taken by the Government to avoid the extinction of so essential an industry. Proposals to this end have been forwarded to the Government.

Valuable technical information is contained in the reports presented by the Branch Committees on Textile Machinery. Generally speaking, textile machinery was adequately manufactured in this country, but the articles taken up by the Branch Committee were textile machines of a highly specialised kind, in the making of which there seemed room for further development. Amongst the machinery dealt with is that required for calico printing, dyeing, hank mercerising, flannelette raising, gas-mantle yarns, silk waste, lace and embroidery making, latch needly making, &c.

The Branch Committee on Machine Tools and Small Tools give a list comprising a number of machines which are not adequately made in this country, and in the making of which there is room for further development. Among these are mechanics' fine tools, portable electric tools, lathe and drill chucks, and many other kinds of machine tools.

It is impossible to summarise all the Branch Committees' reports in a newspaper article. Generally speaking, however, they go to show that whilst in many fields British industry was more firmly established and more successful than is sometimes supposed, there are nevertheless in nearly all directions openings for manufacturers with enterprise.

The committee have agreed that *bona fide* inquirers interested in the manufacture in Britain of any particular article may be put in touch with the chairman of the Branch Committee concerned to obtain such information as is available and advice as to their prospects in entering upon a new field of industry. Such inquirers will be able to obtain at the Ministry of Reconstruction all the information made available by the Branch Committees, except that which is of a confidential nature.

PRICES OF IRON.

THE Minister of Munitions gives notice that the advance of 15*s.* per ton in the price of bar iron for home sales, which was announced on December 30, 1918, as coming into force on February 1, 1919, also applies to prices of rolled edges iron, sheared iron tube strip and iron plates and sheets for home sales, making the basis prices of these as follows :—

	Per Ton Net f.o.t. Makers' Works. £ *s.* *d.*
Rolled edges iron	16 15 0
Sheared iron tube strip	19 15 0
Iron plates and sheets, ¼ in. thick and upwards	18 5 0
Iron plates and sheets, under ¼ in. thick to $\frac{3}{16}$ in. thick, inclusive...	18 15 0

Notice is further given of the following advances to take effect as from February 1, 1919, for home sales.

The price of bar iron, rolled edges iron, sheared iron tube strip and iron plates and sheets will be advanced 15*s.* per ton, making the price as follows :—

	Per Ton Net f.o.t. Makers' Works. £ *s.* *d.*
Bar iron	16 5 0
Rolled edges iron	17 10 0
Sheared iron tube strip	20 10 0
Iron plates and sheets, ¼ in. thick and upwards	19 0 0
Iron plates and sheets, under ¼ in. thick to $\frac{3}{16}$ in. thick, inclusive...	19 10 0

Marked Bars.—The price of marked bars for home sales will be advanced 10*s.* per ton, making the price 18*l.* 10*s.* per ton net f.o.t. makers' works, from February 1, 1919.

ALUMINIUM.—The price at which the Government are prepared to sell their stock of aluminium has been reduced to 150*l.* per ton for 98 per cent. to 99 per cent. ingot, at which price steps have been taken to stabilise the market. Arrangements have been made in regard to these stocks that they shall be disposed of in such a way as to avoid dislocation in the aluminium industry.

CALCIUM CARBIDE.—In reference to the Calcium Carbide Order in 1917, and to the notice of the Ministry of Munitions issued in the Press and dated November 26, 1918, fixing maximum prices and removing certain restrictions on dealing in calcium carbide, notice is given by the Minister of Munitions that on and after February 1, 1919, the maximum prices for dealings in calcium carbide are amended, and shall be as follows for quantities of 110 lb. and over, exclusive of carriage charges, namely, 30*l.* per ton for lump sizes, 30*l.* 10*s.* per ton for granulated sizes up to 15/25 m.m.

THE LATE MR. FRANK EDWARD ROBINSON.—We regret to have to announce the death, which occurred at his sister's residence, 10, Leyland Road, Lee, S.E., of Mr. Frank Edward Robinson, consulting engineer, late of 13, Victoria Street, Westminster. Mr. Robinson was 74 years of age. He entered the Institution of Civil Engineers in April, 1875, and was made a full member of that Institution in January, 1895. He served a pupilage course of three years, from January 1, 1867, to Mr. Eugenius Birch, with whom he remained for several years as an assistant, when he was engaged, among other works, upon the Hastings Pier (as resident engineer), the Westgate Sea Defences, Brighton Aquarium, Ilfracombe Harbour, Scarborough Pier, Weston-super-Mare Pier, Port Adelaide Wharf, &c. He was then engaged upon the Scarborough and Whitby Railway, the Scarborough Aquarium, Truro Water Works, Blackpool Pier extension, West Surrey Water Works, and others. Mr. Robinson later on established a civil engineering consulting practice in Westminster.

CONCRETE OIL TANKER.—The first 1,000-ton seagoing concrete oil tanker was successfully launched at 9.30 a.m. on the 16th inst. by H.R.H. the Crown Prince of Roumania at the Poole Shipyard, Dorset. This oil tanker is 190 ft. between perpendiculars, by 33 ft. beam, by 15 ft. 6 in. deep, and has been built to the order of the Controller-General of Merchant Shipbuilding, who has supplied the general arrangement drawings and specifications to which the vessel was built. It will carry 800 tons of oil on a 12-ft. draft and 1,000 tons on a 13-ft. 8-in. draft. The detailed designs were prepared under the direction of Mr. E. O. Williams, B.Sc., A.M.I.C.E., and the vessel was built by Messrs. Hill, Richards and Co., Limited, to the survey of the British Corporation Registry of Shipping. The exterior finish of the hull is excellent, and it is interesting to note that it is not proposed to coat the interior surface of the concrete, as it has been found that the special concrete of which the ship is made is impermeable, and immune from corrosion by the oil.

PROGRESS IN TURBINE SHIP PROPULSION.*

By Mr. FRANCIS HODGKINSON.

(*Concluded from page 95.*)

Concerning steam turbine details that differ from land practice because of their application to ships, there are the following :—

Governing Arrangements.—With the old reciprocating engines, racing in heavy weather was always to be reckoned with. While governing arrangements were sometimes furnished by the builder, they usually passed most of their existence in a store-room locker. While the reciprocator may accelerate rapidly, it may generally run at proportionately higher relative speeds than the turbine without injury.

With the direct-connected turbine, governors used always to be fitted, but were subsequently found to be of no particular value because the small diameter high-speed propellers always being given the maximum submergence seldom came out of water with the vessel pitching. With the geared turbine the propeller dimensions revert to that of the reciprocating engine, and while because of its inertia the turbine and gear may accelerate less rapidly than the reciprocator, very material increased speeds would be destructive. Therefore, a very dependable regulating mechanism is desirable which must at least have some semblance of being able to regulate, and must not be a mere stop governor which, on the speed reaching a predetermined limit, will slam shut an automatic valve. Arrangement of governing employed by the Westinghouse Company is exhibited in Figs. 23 and 24, annexed.

Fig. 23. MARINE GOVERNOR.

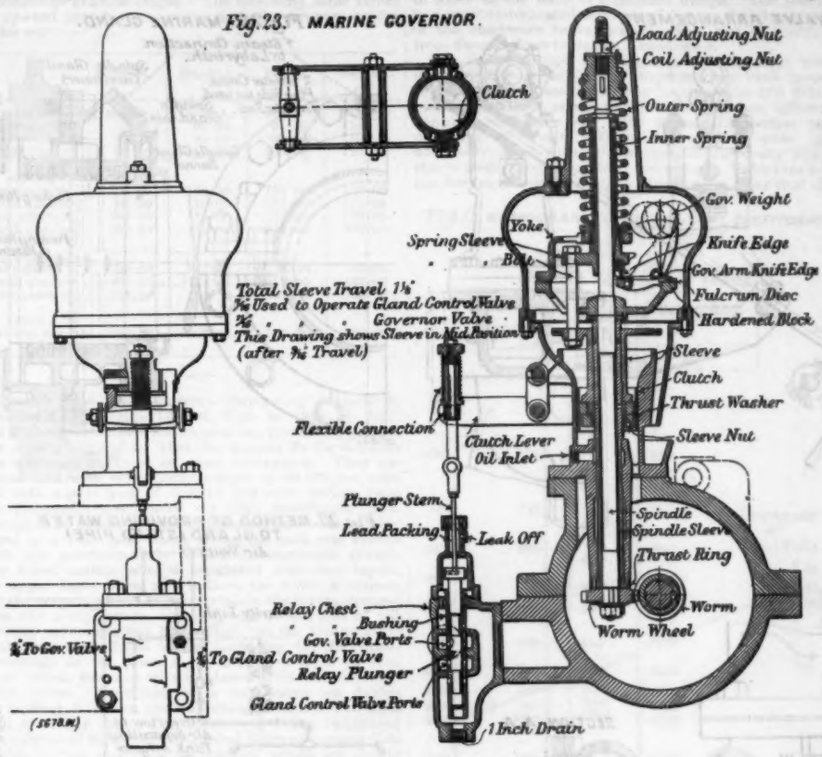
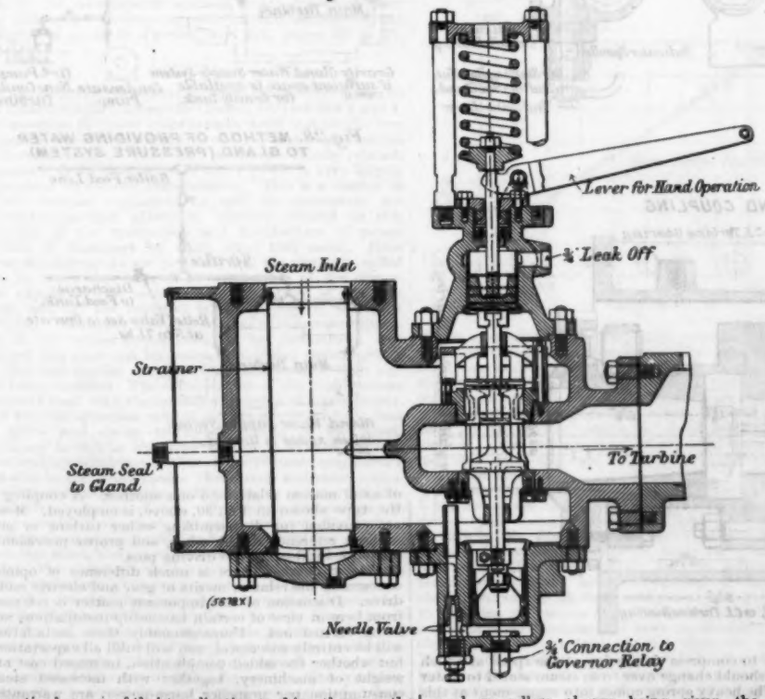


Fig. 24. MARINE GOVERNOR VALVE.



Governing Valve.—With the direct-connected turbine, governors used always to be fitted, but were subsequently found to be of no particular value because the small diameter high-speed propellers always being given the maximum submergence seldom came out of water with the vessel pitching. With the geared turbine the propeller dimensions revert to that of the reciprocating engine, and while because of its inertia the turbine and gear may accelerate less rapidly than the reciprocator, very material increased speeds would be destructive. Therefore, a very dependable regulating mechanism is desirable which must at least have some semblance of being able to regulate, and must not be a mere stop governor which, on the speed reaching a predetermined limit, will slam shut an automatic valve. Arrangement of governing employed by the Westinghouse Company is exhibited in Figs. 23 and 24, annexed.

The governor is of the ordinary fly-ball type, the weights being carried on knife edges, and all working parts arranged to be under forced lubrication. The governor controls the valve shown in Fig. 24 by means of the steam relay, so that the connection between the turbine and the governor valves is merely a pipe, thus eliminating the necessity of connecting links, levers, etc. The relay may be moved by hand at any time by depressing the small spring that is above the relay. In this manner assurance may be obtained at any time without interfering with the operation of the vessel that the governor control valve stands ready to control should the governor weights, with a rise in speed, go to their outer position. With cross-compound units both high and low-pressure elements are provided with a governor, each capable of controlling the valve, that is, either governor may reduce the flow to the turbine, or in other words, whichever governor is running fastest will control the steam. It is usual to adjust the governor springs so that they will regulate at 10 per cent. above normal speed.

Concerning the governor valve, it is of the poppet valve type and actuated by the two pistons above and below in conjunction with the spring. Both pistons have full steam pressure at all times on their inner sides. The outer side of the upper one is open to the atmosphere. The lower side of the lower piston receives high-pressure steam through a needle valve. The lower side of the piston is also connected with the relay adjacent to the governor which will control the pressure under this piston, and hence the position of the valve.

While the regulating characteristics of this apparatus would hardly meet the rigid requirements for turbines driving dynamos, it is simple and regulates with more than sufficient accuracy for the purpose.

Manœuvring Valves.—An important detail, at least important to the watch engineer, is the manœuvring valve. Many shipbuilders—for economy, we presume—are content to merely furnish two throttle valves, one for ahead and the other for astern, with the possibility of admitting steam to both the ahead and astern elements at one and the same time. It has been the practice of the Westinghouse Company to furnish a manœuvring valve operated by a single hand wheel. Motion in one direction gives steam to the ahead, and in the other direction to the astern elements. The design of this valve is as shown in Fig. 25, page 124. An important feature is that the valves themselves are single disc, balanced valves, so that there is but a single ground seat for each valve which may easily be maintained bottle tight. They are balanced by the piston above, rendering their operation easy. With this valve mechanism the turbines are easily brought from full speed ahead to full turbine revolutions astern in 20 seconds, or *vice versa*.

In all cases the manœuvring valve is arranged so that it is always employed, no matter what may be the valve arrangements or what the method of operation; that is, whether both turbines are operating, or only one in case of disablement, as shown in Fig. 2, page 42 *ante*.

Turbine Glands.—Most builders of marine turbines have employed a labyrinth type of packing for the turbine glands; some of them a combination of this with spring packing rings of one kind or another. There is no pretence of these glands being steamtight. To prevent ingress of air, which would interfere with the condenser performance, they are provided with a steam connection for admitting high-pressure steam for sealing so that there shall be a leakage of steam, which will do no harm, rather than one of air. It is found in practice that absolutely to preclude any air leakage there must be a superabundance of steam admitted which will blow, in considerable volumes, into the engine-room. A turbine gland used to be regarded as one of the difficult problems of design detail until, in 1903, the Westinghouse Company devised what is known as the water gland. It merely comprises a centrifugal pump runner operating in a casing which, if furnished with water at the axis, would raise that water to some 10 lb. higher pressure than the maximum pressure against which the gland is designed to pack. In service its periphery, is furnished with water at some 5 lb. greater pressure than the maximum pressure at which the gland is to pack, thus providing a water annulus at the outer part of the gland, forming a hermetic seal which is very effective. For condensing turbines a water pressure of 5 lb. gauge at the periphery of the gland is satisfactory. This simple device rendered an exceedingly difficult detail one that could be forgotten, and obviously has its application to marine installations.

The design of this gland as applied to marine installations is shown in Fig. 26, page 124, in which there is a combination of the water gland above described for use when operating at anything above half-speed, and combined therewith is a simple steam labyrinth for use when running at speeds below one-half or when standing by. This labyrinth is embryotic as compared with labyrinth glands as generally understood, and no attempt is made to have it particularly steamtight because of its being used only when manœuvring or standing by.

A reliable method of furnishing water at the proper pressure to the glands is important and easily arranged for in land installations by pumping all or a portion of the condensate to an overflow at the required elevation, or providing a tank with a float valve at this location.

For merchant ships there is usually head room enough, and the condensate is usually elevated a sufficient height above the machinery to furnish the required pressure as shown in Fig. 27, page 124, and the system is quite automatic, requiring no adjustment.

* Report, slightly abbreviated, read before the Society of Naval Architects and Marine Engineers, at Philadelphia, on November 14, 1918.

On vessels where no head room is available, it is customary as shown in Fig. 28, below, to provide for taking a small quantity of water from the feed line in which an orifice is provided, which will pass but little more than that required for the sealing of the glands. This water is carried to the gland system and there is provided a relief valve, by-passing the water not required back to the feed tank, thus maintaining the proper water pressure on the gland system. The gland casings may be removed for cleaning or inspection without otherwise dismantling the turbine.

With this combined labyrinth and water gland, provision must be made to turn sealing steam on and gland water off to the gland when reducing to below half-speed, and similarly to turn the steam off and the water on when accelerating above this speed. For merchant ships it is entirely satisfactory to provide two valves, one for the water, the other for the steam, located adjacent to the manœuvring valve, which may be readily manipulated by the man handling the valve. With war ships, however, which require to manœuvre more frequently, an automatic valve may be provided, operated in conjunction with the turbine governor shown in Fig. 23, page 123. The turbine governor is provided with two springs and its travel is divided into two zones. The inner travel of the governor weights is opposed by the light spring only, the governor weights being able to compress this spring at the speed at which the gland should change over from steam sealed to water sealed. The heavy spring comes into engagement at this speed, but the governor weights are unable to compress the two springs together until the turbine reaches the speed corresponding to which the governor should regulate the steam supply to the turbine.

Motion of the governor through the first part of its travel will, by means of the relay which it operates, either relieve or impose pressure in the chamber "X" of the gland control valve, Fig. 29, above, causing motion of the valve to either apply water or steam, or *vice versa*, according to whether the turbine is accelerating or retarding.

Couplings.—An important detail is the turbine coupling. To permit free motion of the floating pinion frame there is a flexible shaft provided between the turbine and pinion which provides the necessary element of flexibility. The turbine and gear must be capable of axial motion relative to one another. A coupling of the type shown in Fig. 30, above, is employed. Means are provided for disassembling either turbine or gear without reference to the other, and proper provision is made for lubricating the driving pins.

Electric Drive.—There is much difference of opinion concerning the relative merits of gear and electric motor drive. Discussion of this important matter is refrained from here in view of certain battleship installations now being carried out. Unquestionably these installations will be entirely successful, and will fulfil all expectations, but whether the added complication, increased cost and weight of machinery, together with increased steam consumption per propeller horse-power, are warranted, can be shown only by the development of the future.

One system of electric motor drive suitable for the merchant marine has been proposed which has promise of economy greater than that hitherto attained. The proposition is to provide a number of relatively small Diesel engines whose cylinders shall not exceed a diameter of, say, 10 in., or within the limits where absolute reliability may be expected. These would be coupled

Fig. 25. MANŒUVRING VALVE ARRANGEMENT.

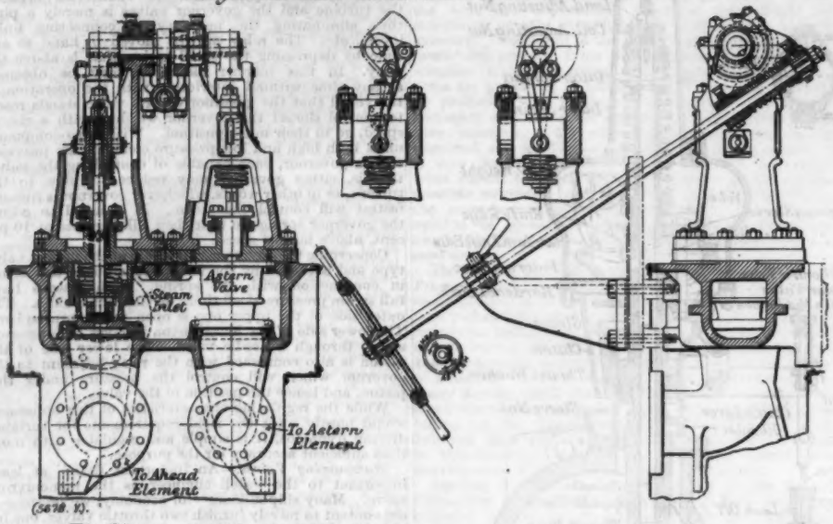


Fig. 26. MARINE GLAND.

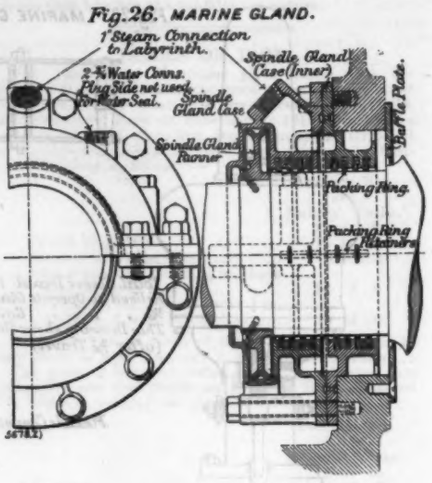


Fig. 27. METHOD OF PROVIDING WATER TO GLAND (STAND PIPE).

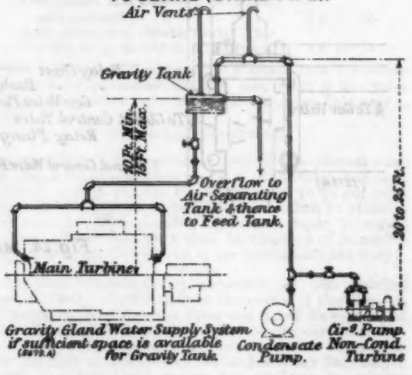

Air Vents
Gravity Tank
10 Ft. Min. 15 Ft. Max.
Overflow to Air Separating Tank & thence to Feed Tank.
20 to 25 Ft.
Main Turbine
Gravity Gland Water Supply System if sufficient space is available for Gravity Tank.
(5678.A)
Condensate Pump.
Cir.g Pump. Non-Cond. Turbine

Fig. 28. METHOD OF PROVIDING WATER TO GLAND (PRESSURE SYSTEM).

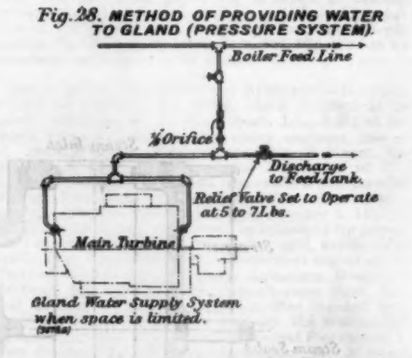

Boiler Feed Line
⅛" Orifice
Discharge to Feed Tank.
Relief Valve Set to Operate at 5 to 7 Lbs.
Main Turbine
Gland Water Supply System when space is limited.
(5678.B)

Fig. 29. GLAND CONTROL VALVE.

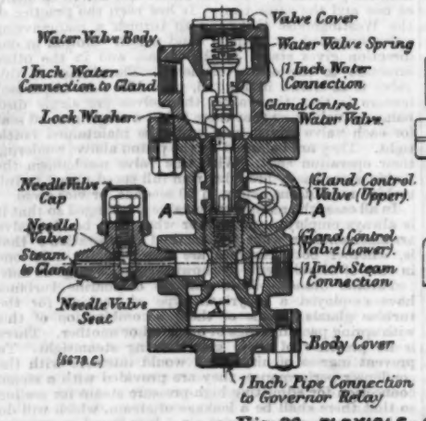
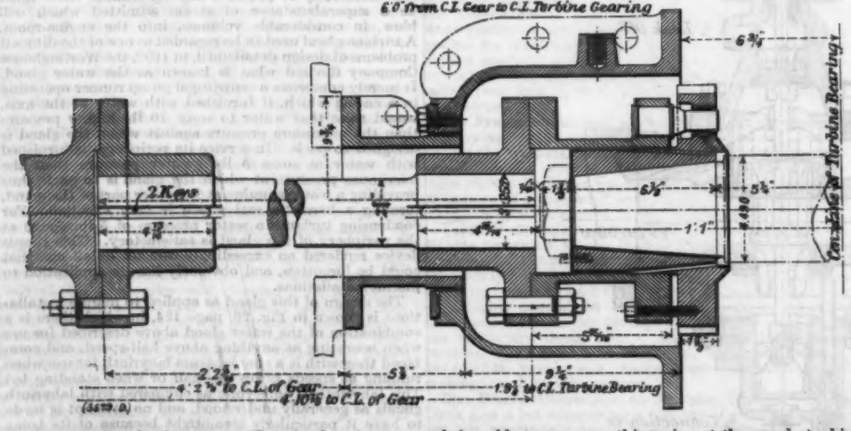


Fig. 30. FLEXIBLE SHAFT AND COUPLING



to dynamos which in turn would operate a motor driving the propeller. The locations of the engines may be where desired without reference to the propelling motor.

GERMAN STEEL PRICES.—The rise of prices for steel products in Germany during the war has passed through a number of gradual stages. The following table shows the upward march of the prices since the commencement of the war :—

—	Ingots.	Bundles.	Plates.	Sections.
1914.	marks.	marks.	marks.	marks.
Second quarter	82·50	95·00	97·50	110·00
Third quarter ..	82·50	95·00	97·50	110·00
Fourth quarter	90·00	102·50	105·00	110·00
1915.				
First quarter ..	90·00	102·50	105·00	120·00
Second quarter..	92·50	110·00	112·50	120·00
Third quarter ..	102·50	115·00	117·50	130·00
Fourth quarter..	102·50	115·00	117·50	130·00
1916.				
First quarter ..	102·50	115·00	117·50	130·00
Second quarter..	107·50	122·50	127·50	140·00
Third quarter ..	127·50	142·50	147·50	160·00
1919.				
First quarter ..	285·00	300·00	305·00	320·00

THE SYSTEM IRON-COPPER.—Continuing a research, conducted by R. Ruer and C. Fick, in 1913, R. Ruer and F. Goerens confirm the impression, previously gained, but merely alluded to, that the system Fe-Cu behaves like a system of three or more substances. They experimented with electrolytic copper of 99·95 per cent. and with a pure iron of 0·0012 per cent. carbon from the Dommeldingen works or with electrolytic iron. Lumps of 25 grains of each of these metals were quickly fused in a Tammann furnace, and the melt was stirred with the porcelain tube of the thermocouple sheath. The fused metals always separated into two layers, the upper layer being rich in iron, the lower in copper, but the proportion of the two metals in the layers changed with the temperature, and the middle portion of the freezing curve was not horizontal ; as the temperature went down from 1,569 deg. to 1,440 deg. C., the copper percentage in the lower layer decreased from 90·6 to 82·3, which was not in accordance with the freezing-point curve. Impurities were not taken up during the melting, however, nor was nitrogen absorbed to more than 0·03 per cent., the operations being conducted in a current of nitrogen. Ruer and Goerens suggest that in this system molecular complexes, which are slowly formed and decomposed again, behave like a third substance. That would be a contradiction of the phase rule, as the investigators are well aware, for which they can adduce no further support. A full account of the research is given in *Ferrum*, vol. xiv, pages 49 to 61, 1917.

THE GERMAN INDUSTRIAL OUTLOOK.—According to the *Zeitschrift für angewandte Chemie*, for October 1 and 4, the question of power concentrates itself around the two points of water-fall utilisation and the wider application of electric energy. These two points are closely related, inasmuch as the utilisation of water-power is very largely dependent on electric transmission. This is a matter to which German engineers, as well as statesmen, are turning expectant attention. Closely related to this question of the production and distribution of power is that of transport by road, river and canal. Here great developments are possible, and are urgently called for, to meet the altered circumstances of the times. The supply of raw materials is a question of the first rank, and for the moment is, for Germany, the most pressing. Germany's wealth in coal is an assured quantity in the future development of her industries. But the cry has gone out for more economical consumption. To this end special scientific institutions have been and are being founded. The conservation of the coal reserves connects itself with the further utilisation of water-power. But the fuel question cannot be thought of without that of quick and cheap transport arising in the mind. Germany is rich in iron ores as well as in coal, though their quality is inferior to that of her Western neighbour's deposits in the Briey basin. Improved and more economical methods of working will go far to counter-balance a relative poorness of ore. Meanwhile the country is being carefully searched for yet undiscovered deposits. Though Germany may be for long cut off from supplies from the West, she may look for larger imports from the East. The country's wealth in zinc is a factor to reckon with, while her ability to produce aluminium is unlimited. Another raw material of growing importance is mineral oil. With a view to obtain a larger home supply of oil, borings are being made in likely places all over Germany. Some of them are already yielding a promising supply. Of imported oil, nearer sources than the United States are likely to be found. The question of substitute materials must not be lost sight of ; their number is surprisingly great, and some of them, doubtless, have come to stay. In that direction a notable expansion of industry has been brought about by the war. Restricted in some directions, new outlets have been found in others. In view of the statements made in the German secret memorandum referred to in our article on page 32 *ante*, the above remark to the effect that "Germany is rich in iron ores" should be noted.

ON THE HEAT TRANSFERENCE IN SURFACE CONDENSERS.*

By Dr. ALFRED W. PORTER, F.R.S., Fellow of University of London University College.

IN spite of the large amount that has been written upon condensers, no complete rules have yet been given to serve as the basis of condenser design. The matter is a very complicated one, especially on the steam side of the condenser tubes, and it would not be possible from theory alone to design a condenser.

The first thorough experimental investigations were made by J. P. Joule.† It is surprising how little known these researches are ; yet they include over 150 determinations of heat transfer with different tubes, different velocities of water and with different velocities and pressures of steam. These experiments were undoubtedly made with all the care and accuracy which characterise Joule's other researches. Unfortunately one datum is lacking which is necessary in order that the

Fig. 1. NOMOGRAM FOR RESULTANT COEFFICIENT OF TRANSMISSION.

$$\frac{1}{k}=\frac{1}{k_1}+\frac{1}{k_2}+\frac{e}{K}$$

TO FIND RES.T COEFF. OF TRANS.	
Join Scales	*Intersecting*
A and B	*C*
C and D	*E*

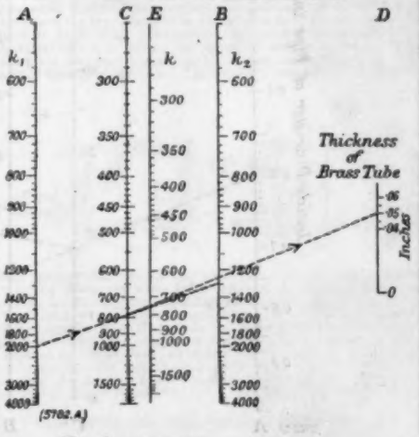
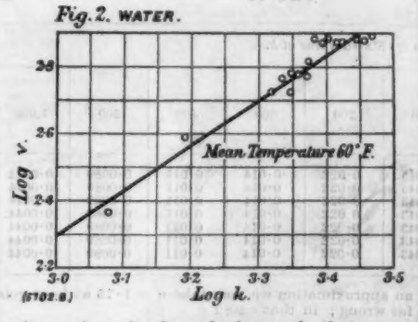


Fig. 2. WATER.



results may be analysed completely, namely, the temperatures of the tubes themselves. The temperatures of the steam on the one side and the circulating water on the other are given ; but with these alone it is only possible to deal with the steam-tube water system as a whole, and the complications which occur on the two sides of the tubes cannot be disentangled from one another. The result is that many of the laws given are incorrect, or at any rate only correct under exceedingly restricted conditions.

Although many other investigations have been made, I am not aware of any which supply this desideratum, except some recent ones described before the Institution in 1913 by Mr. Gordon C. Webster.‡ These seem to be entitled to rank with those of Joule for thoroughness, and in addition they contain data in regard to tube temperatures which were determined by means of a thermocouple. With these additional data it is possible to examine the steam and the water sides separately and finally to combine the laws so obtained so as to elucidate the behaviour of the complete condenser. Mr. Webster does this in part and deduces certain laws ; but he does not leave the subject in such a form as to be most convenient to a designer. The object of the present paper is to describe the results of an independent examination of Mr. Webster's data, and finally to display them, so far as possible, in a form ready for use.

The Coefficients of Transmission.—The quantity made use of to define the property of a condenser is the coefficient of transmission of heat. This is a quantity first introduced by Lord Kelvin in a letter to Joule, dated August 10, 1859, as being most suitable for expressing the results of his researches. It measures heat flowing per unit time per unit area per unit difference of temperature between the fluids on the two sides of the tube wall, and allows for the effect of any badly conducting films which may be adherent to the wall. Owing to the presence of these films the effective conductivity of the layer intervening between the two fluids is quite small compared with the true conductivity of the metal of the wall. The films themselves are usually exceedingly thin. We may define the coefficient k by the equation :

$$T-t_2=\frac{H}{kA},$$

where T = temperature of the steam.*
t_2 = temperature of the water.
A = mean area of flow of heat.
H = heat transference per unit time.

In the metal itself the heat flow is given by the equation :

$$\theta_1-\theta_2=\frac{H\,a\log\frac{b}{a}}{KA}=\frac{H(b-a)}{KA}$$

approximately where θ_1 and θ_2 are the temperatures of the pipe itself on the steam side and water side respectively, K is the thermal conductivity of the material of the pipe, and a the inside radius of the tube. We can, therefore, write down three equations—one for each film and one for the metal :

$$\theta_2-t_2=\frac{H}{k_2A} \quad \text{(water side)}$$

$$\theta_1-\theta_2=\frac{H(b-a)}{KA} \quad \text{(tube)}$$

$$T-\theta_1=\frac{H}{k_1A} \quad \text{(steam side)}$$

Hence, by addition,

$$T-t_2=\frac{A}{H}\left[\frac{1}{k_2}+\frac{b-a}{K}+\frac{1}{k_1}\right],$$

which can be written :

$$T-t_2=\frac{H}{kA}$$

The value of k is the resultant or effective or overall coefficient of transmission, and this given in terms of the separate coefficients by the equation :

$$\frac{1}{k}=\frac{1}{k_1}+\frac{b-a}{K}+\frac{1}{k_2}$$

Since each coefficient is a ratio such as K/s where K is the conductivity and s the thickness of the film referred to, we can write :

$$\frac{1}{k}=\frac{e_1}{K_1}+\frac{e}{K}+\frac{e_2}{K_2}$$

The middle term is often quite small compared with the others, and it can then be neglected. The complete calculation of k with an allowance for the middle term can, however, be made exceedingly readily by means of an alignment chart. Such a chart is given in Fig. 1.

Construction and Use of Chart, Fig. 1.—Supports A and B are scaled as reciprocals of k_1 and k_2, and are labelled according to the corresponding values of k_1 and k_2 themselves. The two scales are equal.

Support C is midway between A and B ; it carries a scale of reciprocals of k uncorrected for the middle term. The scale is half the other two.

Support D carries a uniform scale of thicknesses of pipe assumed to be of brass. For convenience this scale is chosen so that e/K for brass is 10 times the scale of C ; it is labelled in inches. It can be placed anywhere and with any origin.

Support E is at one-eleventh the distance from C to D, and it is labelled so that lines drawn from the zero of scale D cut both C and E at the same figures. To use the chart, join the points on A and B which denote the values of k_1 and k_2, by a straight line. Join the point at which this line cuts C with the point on D which denotes the thickness of pipe. This second line cuts E at a point denoting the resultant coefficient of transmission.

An example is shown by E means of the dotted lines on the chart.

Water side k_2 = 1,290 British thermal units/[square feet : degree Fahrenheit : hour.].

Steam side k_1 = 2,000 British thermal units/[square foot : degree Fahrenheit : hour].

Brass tube 1/20 in. thick.

Resultant coefficient of transmission = 740.

In Parts II and III are discussed the evidence in regard to the dependence of k_1 and k_2 upon the conditions in the condenser.

PART II.—THE HEAT TRANSFER FROM THE TUBE TO THE CIRCULATING WATER.

The theoretical principles underlying the transmission of heat from a pipe to water passing through it were first enunciated by Osborne Reynolds. The flow of the water itself may be either non-turbulent when the velocity is small, or turbulent when the velocity exceeds a certain minimum value, which in straight, smooth,

* Paper read at the Institution of Shipbuilders and Engineers, in Scotland, November 12, 1918.

† Trans. Royal Society, 1861 ; also Collected Papers, vol. i, page 502, on "The Surface Condensation of Steam."

‡ Trans. Institution of Engineers and Shipbuilders in Scotland, vol. lvii, page 58.

* The notation is the same as in Mr. Webster's paper.

circular pipes may for practical purposes be taken as given by the formula :

$$\text{Critical velocity in feet/minutes} = \frac{\text{viscosity in foot-pound-second units}}{24{,}000 \times \text{specific gravity} \times \text{diameter of pipe in inches.}}$$

Although in the general problem of the interchange of heat we are often concerned with velocities below the critical value, it may be taken for granted that in usual condenser practice this will never be the case. The transfer of heat in the non-turbulent case is very small, the coefficient of transmission being only about 4 British thermal units/[square foot : degree Fahrenheit : hour] (as is shown by an investigation which I have recently made, an account of which will be published in another place). Even when the flow is turbulent it often does not rise above this value (economisers, tubular boilers, &c.). When thorough turbulence is attained very much larger values are obtainable—extending into four figures—and it is these with which we are here concerned. The controlling factor in these cases is the film of slowly moving liquid in the immediate neighbourhood of the wall of the pipe. In the main body of the pipe heat is convected across by the movements of the turbulent fluid ; while in the film the transmission takes place by thermal conduction alone. The coefficient of transmission across the film k_2 is given by K_2/e_2, where K is the thermal conductivity of the material of the film and e_2 is its thickness. It is perhaps not always realised how thin a film is necessary to reduce the coefficient to quite a small value. The following table gives the thickness of water films corresponding to various values of the coefficient of transmission.

The value of k is given in British thermal units/[square foot : degree Fahrenheit : hour], or C.H.U./[square foot : degree Centigrade : hour]; a is the inside radius of the film. It will be seen that a change in the film thickness from 0·0044 in. to 0·022 in. reduces the coefficient of transmission from 1,000 to 200.

This table is also instructive in showing the effectiveness of even very thin films of a non-conducting deposit in pipes in reducing the heat transmitted through them.

It becomes of prime importance, therefore, to determine the effective film-thickness in various cases. Unfortunately this cannot be done in any complete manner ; the mathematical treatment of problems in turbulence has not yet progressed far enough. Information can, however, be obtained by applying the method of dimensions. This was done by Osborne Reynolds ; perhaps the following version may be more easily understood.

The resistance to the steady flow of a fluid (gas or liquid) in a cylindrical pipe will depend, in some manner, upon the diameter, and upon the density, viscosity, and velocity of the fluid. If it be assumed that each of these enters only as a power of itself, we can write :

Resistance per unit surface = constant $\times d^x \mu^y \rho^z v^n$

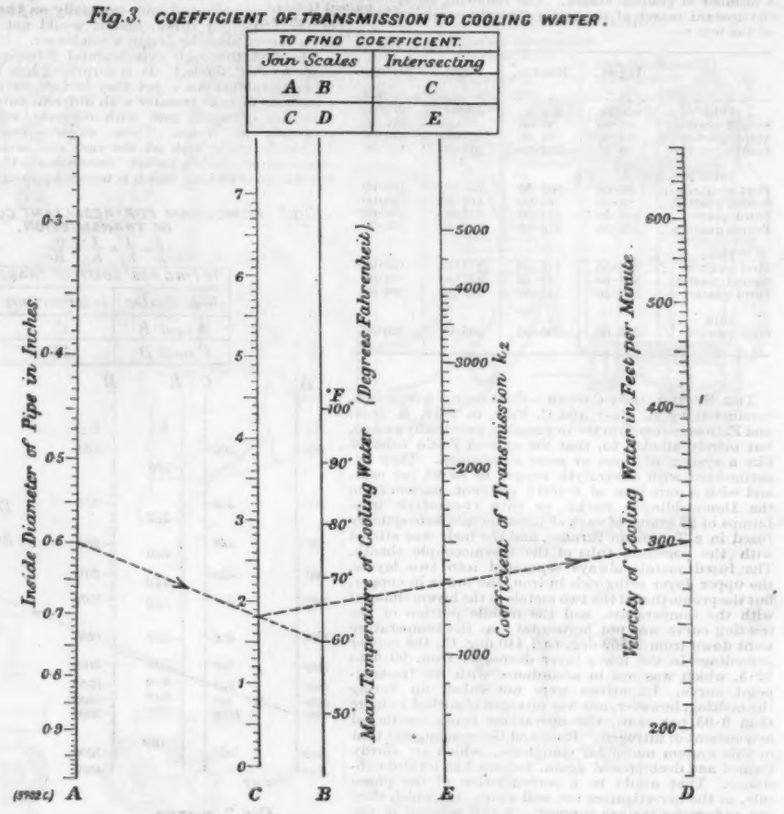
Where d = diameter, μ = viscosity, ρ = density, v = velocity, and x, y, z, n are the powers concerned.

Now the physical dimensions of both sides of this

The index n cannot be determined in this way ; it must be determined by experiments either on heat transfer or on resistance to flow. Stanton* gives $n = 1{\cdot}73$ for smooth glass pipes and 1·86 for smooth copper, increasing to 2 as a limit for rough metal. An examination of Joule's results, which I have recently made, led me to the value 1·74. It is probable that as

In Fig. 2 the straight line corresponds to a variation according to the three-quarter power of the velocity. It is seen to fit the observations as well as may be. A shorter set with mean temperature 80 deg. F. was dealt with in the same way. Taking the two sets together, the absolute constant is found to be about 0·078 when the diameter is expressed in inches, the density is

Fig. 3. COEFFICIENT OF TRANSMISSION TO COOLING WATER.



Film Thickness in Inches for Stated Value of k.

k / a—Inches.	5	10	20	40	50	100	200	300	400	500	1,000
0·6	1·93	0·61	0·26	0·26	0·092	0·045	0·022	0·014	0·011	0·0089	0·0044
1·2	1·26	0·52	0·24	0·11	0·090	0·045	0·022	0·014	0·011	0·0089	0·0044
2·4	1·04	0·47	0·23	0·11	0·089	0·043	0·022	0·014	0·011	0·0089	0·0044
3·6	1·01	0·46	0·23	0·11	0·087	0·043	0·022	0·014	0·011	0·0089	0·0044
4·8	0·96	0·46	0·22	0·11	0·086	0·043	0·022	0·014	0·011	0·0089	0·0044
6·0	0·92	0·45	0·22	0·11	0·086	0·043	0·022	0·014	0·011	0·0089	0·0044
7·2	0·91	0·45	0·22	0·11	0·086	0·043	0·022	0·014	0·011	0·0089	0·0044

equation must be the same ; i.e., the fundamental units of mass M, length L, and time T must enter in the same way on both sides. Writing these dimensions, as usual, in square brackets, we obtain :

$$\left[\frac{M}{LT^2}\right] = \left[L\right]^x \left[\frac{M}{LT}\right]^y \left[\frac{M}{L^3}\right]^z \left[\frac{L}{T}\right]^n$$

Hence :

$$1 = y + z$$
$$-2 = -y - n$$
$$-1 = x - y - 3z + n$$

The second equation gives :

$$y = 2 - n$$

whence the first equation gives :

$$z = n - 1$$

and the third equation gives :

$$x = n - 2$$

so that—

$$R \text{ varies as } d^{n-2}\, \mu^{2-n}\, \rho^{n-1}\, v^n$$

where the value of n is left undetermined.

Now the value of R must be equal to :

$$\mu \times \text{gradient of velocity at surface.}$$

Writing this gradient v/f where f is a distance comparable with the thickness of the film, we obtain :

$$\frac{1}{f} \text{ varies as } \left[\frac{v\rho}{\mu}\right]^{n-1} d^{n-2}$$

and the coefficient of transmission :

$$k = \frac{K}{f} = \text{constant } K \left[\frac{v\rho}{\mu}\right]^{n-1} d^{n-2}$$

an approximation we may take $n = 1{\cdot}75$ without going far wrong ; in that case :

$$k = \text{constant } K \left(\frac{v\rho}{\mu}\right)^{\frac{3}{4}} d^{-\frac{1}{4}}$$

In order to test this formula by means of Webster's data, I have selected all those cases in which the mean temperature of the water was close to 60 deg. F. (in order that K, ρ, μ, d might all be taken as nearly constant) ; and have plotted the values of log k against log v. The data and calculations from them are given in the following table ; the plot is shown in Fig. 2.

θ_2 = temperature of inner surface of tube.
t = mean temperature of water.
H = heat transferred per minute per square foot.

Data for Circulating Water.

t	v	H	$\theta_2 - t$	k_2
60·4	514	3,950	114·6	2,070
58·9	735	5,410	113·0	2,868
61·0	576	4,380	115·3	2,280
58·3	741	4,670	111·2	2,520
60·1	735	5,500	114·0	2,946
63·1	516	4,730	128·4	2,206
62·8	570	4,890	126·2	2,328
60·0	727	5,450	123·2	2,658
58·7	741	5,420	116·3	2,796
62·8	590	5,110	137·8	2,226
59·9	728	5,500	126·4	2,610
61·3	725	5,680	132·0	2,586
60·8	720	5,480	132·8	2,478
60·9	805	5,510	125·6	3,102

taken as relative density (water = 1), the viscosity is in pounds per foot per second, and the velocity is in feet per minute.

These results are represented in a nomogram* or alignment chart in Fig. 3. By means of this chart the value of the coefficient of transmission k_2 from the pipe to the circulating water can be determined very readily when the independent variables are given. It is, of course, obvious that this chart has application to the whole subject of heat interchange in coolers and heaters of all kinds in which water is the flowing liquid, and its use is not limited to the condenser problem.

Similar charts can of course, be constructed to suit any other liquid ; and they can be extended to gases by an extension to allow for variations of density.

Construction and Use of Chart, Fig. 3.—For the sake of draughtsmen the following instructions are given in regard to the details of the chart :—

Support A carries a logarithmic scale of diameter (copied from a slide rule), and is labelled as diameters in inches.

Support B carries a logarithmic scale of viscosities of water at different temperatures, and is labelled with the corresponding temperatures.

Support C carries an arbitrary intermediary scale of reference ; the distance $\overline{AC}$ is $3 \cdot \overline{CB}$.

Support D carries a logarithmic scale of velocities.

Support E is placed so that $4 \cdot \overline{CE} = 3 \cdot \overline{ED}$. It carries a logarithmic scale, and is labelled so as to give directly the coefficient of transmission from the pipe to the circulating water, taking the average of Mr. Webster's results as the standard.

To find the coefficient, join the point on A denoting the diameter of the pipe in inches with the point on B denoting the mean Fahrenheit temperature of the water. The connecting line intersects support C at a point which must be joined by a straight line to the point on D representing the velocity in feet per minute. This second connecting line cuts the support E at a point which denotes the coefficient required in British thermal units/[square foot : degree Fahrenheit : hour], or C.H.U./[square foot : degree Centigrade : hour].

An example is shown by the dotted lines on the chart.

Inside diameter of pipe = 0·6 in. ; temperature of water, 60 deg. F. ; velocity of water = 300 ft. per minute ; required coefficient of transmission $k_2 = 1{,}290$.

(To be continued.)

* Philosophical Trans. A., 1897, page 67.

* See W. J. Goudie for a detailed explanation of such charts. Trans., Institution of Engineers and Shipbuilders in Scotland, vol. lx, page 288.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in Italics.

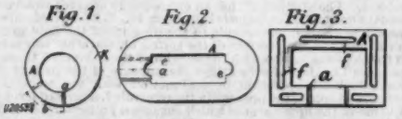
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

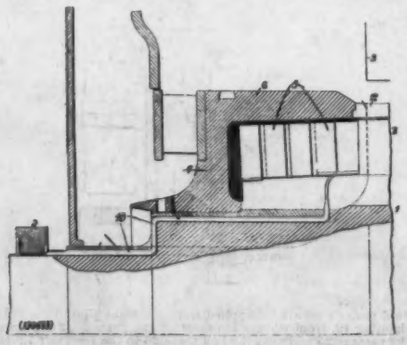
ELECTRICAL APPARATUS.

120,593. The Lancashire Dynamo and Motor Company, Limited, Trafford Park, Manchester, and H. B. Whitmore, Bramhall Lane, near Stockport. Dynamo Electric Machines. (26 *Figs.*) October 8, 1917.—According to the present invention, increased radiation of heat from the magnet coil windings is obtained by arranging the external contour of the laminæ unsymmetrically in reference to the bore, so as to provide radiating fins which project beyond the intervening contour of the completed winding and increased ventilation is obtained by forming recesses in the interior edges or bore of the laminæ, or by slotting or punching holes in the body of the laminæ, so as to provide, respectively, ventilating passage ways between the winding and the magnet, or axially through the body of the winding. The external periphery of the ring A is shaped unsymmetrically in reference to the bore; in Fig. 1 the exterior bounding circle is eccentric to the bore so that when the rings are reversed in assembling, radiating fins K project from the winding. The cut *a* through the ring A is made so that the two edges may be axially displaced to give the ring a helical shape; the cut is made unsymmetrically in relation to the centre line



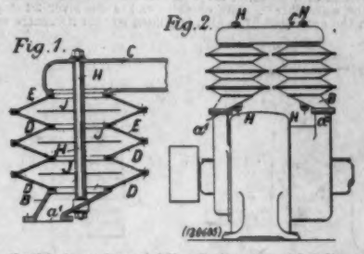
so that when rings are reversed face for face the cut is axially displaced by a distance *b* so as to provide the necessary overlay in assembling the coil. The overlapping parts may be brazed or riveted together, or contact due to axial pressure may be depended upon to ensure electrical contact between the convolutions. Fig. 2 shows the mode in which, by punching or otherwise, recesses *e* are formed in the bore of the laminæ; channels are thus provided, when the rings are assembled, which provide ventilating passage ways extending axially between the winding and the magnet, and through which currents of cooling air are circulated for which suitable end inlets and outlets are provided. Fig. 3 shows the mode in which, by punching or otherwise forming holes or slots *f* in the body of the laminæ, channels are provided when the winding is assembled, which form ventilating passage ways extending axially through the body of the winding, and through which currents of air are circulated for which suitable end inlets and outlets are provided. In each of the rings described the cut *a* may be made unsymmetrically as described in reference to Fig. 1. (*Accepted November 27, 1918.*)

120,653. Vickers, Limited, Westminster, London, and S. F. Barclay, Sheffield. Dynamo Electric Machines. (1 *Fig.*) November 20, 1917.—According to this invention, the end bell for retaining the end connections of the rotor consists of a steel cylinder formed in one piece with a disc which is mounted on the rotor shaft, a gap being left between the rotor core and the adjacent end of the cylinder to prevent magnetic leakage through the latter. The rotor shaft 1 with rotor core 2 and a stator 3 are contained in a casing, part of which is shown at 4. The end connections 5 are retained by the end bell con-



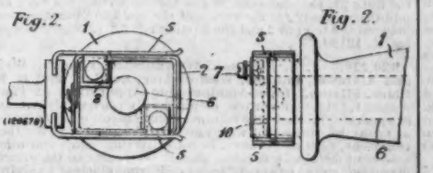
sisting of the steel cylinder 6 formed in one piece with the disc 7 which is mounted on the shaft 1 and is retained in position in the axial direction by a nut 8. A slip ring 9 is connected to the rotor winding by the conductor 10. The end bell can readily be removed without in any way interfering with the slip ring. A gap is left between the rotor core 2 and the cylinder 6. The short lengths of coil that bridge across this gap from the core 2 to the cylinder 6 are supported by extending the usual rotor slot wedges 12 beyond the core and registering them under the cylinder 6 as shown. (*Accepted November 27, 1918.*)

120,605. Le-Thermo Patents, Limited, Manchester, B. Longbottom, Alderley Edge, and E. Greenhalgh, Rusholme, Manchester. Dynamo Electric Machinery. (15 *Figs.*) November 9, 1917.—This invention relates to that enclosed type of dynamo-electric machines in which the enclosed air is circulated in succession through the machine casing and through an airway connecting an air outlet and an air inlet on the casing, the walls of the said airway being arranged to form suitable heat-exchanging surfaces so that the circulating air is cooled as it passes through the airway. According to the present invention, the airway through the heat-exchanging surfaces comprises two vertical portions, one connected to the inlet *a*¹ and one connected to the outlet *a*², said two portions being built up of units and connected by a cross passage-way C at the top. The units composing each vertical portion comprise a pair of



conically dished annular metal discs D, E, making joint alternately at their inner and outer surfaces, and each vertical portion is carried by an adaptor seating B, the two vertical portions being connected together at the top by a cross-connecting casing C. The sets of units in each vertical portion are connected together and to their seating and to the connecting casing by a central bolt H on which are threaded baffle plates J separated by distance ferrules. (*Accepted November 27, 1918.*)

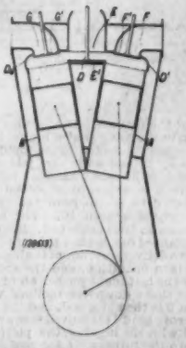
120,678. British Insulated and Helsby Cables, Limited, Prescot, and L. B. Wilson, Prescot. Fuse Carriers. (4 *Figs.*) February 7, 1918.—This invention has reference to removable electrical fuse carriers or connecting and disconnecting devices of the type comprising a hand grip having a metal contact part at each end. 1 represents the hand grip of insulating material and 2 is one of the metal contact parts on its ends. 5 are the terminal contact socket devices to which will be connected the electrical cable. The handle 1 has a hole 6 through it,



and through this hole the fuse wires pass from one contact device 2 to the other, the wires being fastened to the metal part 2 by screws 7, screwing into metal lugs on the front edge of the part 2. The part 2 is relatively thin, and is made of a strip of metal with a corrugation 10 in it, bent to the rectangular form shown, the ends of which are connected together; this connection being effected by tongues cut out of the one end, and passed through holes in the other end, and pressed on to the metal of the other, so that it becomes a rigid tube or open box; rigidity being given it by the inbent corrugation 10. (*Accepted November 27, 1918.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

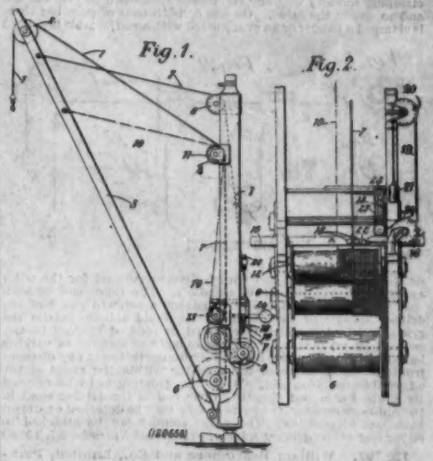
120,613. H. R. Ricardo, Westminster, London. Internal-Combustion Engines. (1 *Fig.*) November 13, 1917.—This invention relates to internal combustion engines operating on the four-stroke cycle. According to this invention, an engine operating on the four-stroke cycle is provided with twin cylinders A, B, relatively inclined about a common crankshaft and having a common combustion chamber formed in a head D, D1, D2, which is common to the two cylinders. The gases flow into and out of these twin cylinders through three valve-controlled ports E, F, G, each of large area, and all disposed in the common cylinder head. A single inlet port E, of large area, is disposed in that part of the combustion chamber which lies between the cylinders, while the exhaust ports F, G are disposed centrally



at the ends of the cylinders. The valves E1, F1, G1 controlling these ports are operated either directly or indirectly from an overhead camshaft. Preferably, the inlet valve E1 is operated directly by a centrally-disposed overhead camshaft, while the two exhaust valves F, G1 are operated indirectly from the same camshaft by means of rocker levers. With this construction of cylinders and arrangement of the ports, the port area can be increased to a considerable extent as compared with the normal design, and without unusual or undesirable formation of the shape of the combustion chamber, and in a manner which allows a high compression ratio to be employed. Further, the inlet valve E1 is so positioned that the flow from this valve into the two cylinders A, B is free from any restriction or any abrupt change of direction. (*Accepted November 27, 1918.*)

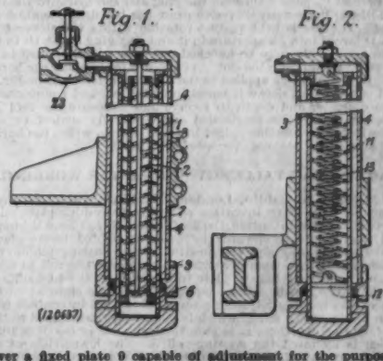
LIFTING AND HAULING APPLIANCES.

120,650. T. G. Gardner, Seven Kings, and G. D. Hepburn, Ibrox, Glasgow. Jib Cranes. (4 *Figs.*) November 28, 1917.—The invention has for its object to provide a safety device by which the movement of the load in both directions and/or the alteration of the radius of the jib, when applied to a jib crane may be limited; the invention also has for its object to provide means whereby the jib and/or the load shall be supported in the event of failure of the human element or of the supporting ropes, chains, or gearing controlling or operating the jib and/or the load. According to the present invention, a safety device of the kind described comprises the combination with a brake for the winding drum, of means for applying the brake operated by the travel of the rope along the winding drum, for example, a bar operatively connected to the brake and to the rope, as by two projections, extending from the bar, one on each side of the rope. The hoisting rope 1 passes over sheaves 2, 4 to the main winding drum 6. The jib luffing rope 7 passes over a sheave 8 to its winding drum 9. An auxiliary rope 10 is also connected to the jib 3, and passes over a sheave 11 to a supplementary winding drum 12. The drum 12 is connected through gearing to the drum 9. 13 is a supplementary brake drum connected through gearing to the drum 12. On the front of the crane post 5 is arranged a bar 16 which slides in guides and has two projections 18 between which the luffing rope 7 passes. To the bar 16 is also connected a rope 19, which passes over pulleys 20 and carries a weight 21. The bar 16 is also provided with a depression 22. 23 is a lever to which the brake



band acting on the brake drum 13 is connected. At one end, the lever is provided with two projections between which the auxiliary rope 10 passes. On the other end, the lever has secured to it two depending plates between which is connected a lever which carries at its outer extremity a weight 28. To the lever 27 is secured a roller 30, which is adapted to roll on the bar 16. The operation of the device described above is as follows. When the jib 3 is luffed, the rope 7 unwinds from the drum 9 and, in moving across the drum, presses on the projections 18 of the bar 16, and consequently moves it towards the right. If it is endeavoured to luff the jib beyond the safe radius, the depression 22 moves under the roller 30, whereby the weight 28 is enabled to pull down its lever and operate the brake lever, whereby the brake is applied to the brake drum 13. During the luffing of the jib, the auxiliary rope 10 unwinds from its drum 12, and in taking up a part of the stress of the falling jib it comes into contact with the brake lever, thus forcing the end of the lever upwards and applying the brake, whereby the movement of the jib is controlled. In the event of the main luffing rope 7 breaking, the weight 21 acts immediately to pull the bar with its depression 22 under the roller 30, whereby the brake is immediately applied and the jib is then supported by the auxiliary rope 10. (*Accepted November 27, 1918.*)

120,637. E. Graham, Knock, Belfast, and G. Bowman, Belfast. Fluid-Pressure Jacks. (2 *Figs.*) November 23, 1917.—This invention relates to fluid-pressure operated jacks for use in connection with the jacking-up of motor or like vehicles. According to this invention, the ram of the jack is returned after the pressure is withdrawn, by means of a plurality of co-acting springs. Two compression springs 1, 2 are employed to give the necessary spring return action on the ram 3 of the jack 4. The springs 1, 2 are concentrically arranged, the spring 2 being within the spring 1, and both springs within the ram 3. 7 is a tube or sleeve located between the springs and adapted to slide

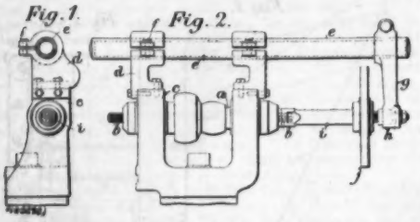


over a fixed plate 9 capable of adjustment for the purpose of varying the compression on the springs. The arrangement is such that when the liquid or fluid, admitted at 23, forces the ram 3 down, the springs will be compressed, and, as the ram extends beyond the jack casing 4, the sleeve 7 will extend outwards with it over the fixed plate 9. When the fluid pressure is withdrawn, both springs will react to return the ram 3. Instead of the two compression springs, a compression spring 11 and a tension spring 13 used in combination may be employed as shown in Fig. 2. The ram 3 and jack casing 4 are made the same as the corresponding parts shown in Fig. 1, and both springs are accommodated within the ram 3. The arrangement is such that when

the fluid pressure forces down the ram 3, the compression spring 11 will be compressed against the plate 12 until the pressure commences to pull on the tension spring 13, which will then be extended, and the plate 12 will move with the movement of the tension spring 13, carrying with it the compression spring, until the limit of movement of the ram 3 has been reached. When the fluid pressure is withdrawn, both springs will react to return the ram, and may, for some portion of the return action, be reacting together. (*Accepted November* 27, 1918.)

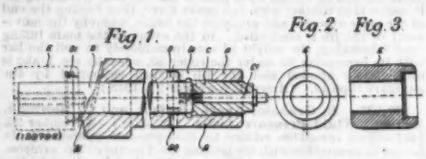
MACHINE AND OTHER TOOLS, SHAFTING, &c.

120,690. A. Tuckley, Sparkhill, Birmingham. Grinding Machines. (2 *Figs.*) March 5, 1918.—This invention relates to grinding machines and comprises means, as hereinafter described, providing for the effective operation of the grinding wheel at extended positions relatively to the main frame of the machine. The driving spindle *a* is provided with projecting screwed ends *b* and is mounted in the bearings of a main frame or standard *c*. To such main frame there are detachably secured a pair of brackets *d* having clamp bosses to receive a bar *e* adapted to slide through such bosses and to be secured at any desired position by clamping screws *f* whereby the bosses are caused to grip the bar and so secure the same. On one or both ends of such bar there is clamped a hanger or an arm *g* fitted with an adjustable bearing *h*



or combined bearing and thrust-piece or support for the outer end of the grinding wheel spindle *i*. The inner end of such spindle is screwed internally to engage a screwed end *b* of the driving spindle of the machine. The said spindle carries the grinding wheel *j*, which is clamped or secured thereon in any convenient manner. By the employment of spindles of varying length the grinding wheel can be set for operation at any distance from the main frame of the machine within the range of the adjustable bar aforesaid. When the grinding is to be effected by a wheel attached directly to one end of the driving shaft in the ordinary manner, the parts *e* and *g* may be detached or drawn back out of position. The wheel spindle can be attached to either end of the driving spindle. (*Accepted November* 27, 1918.)

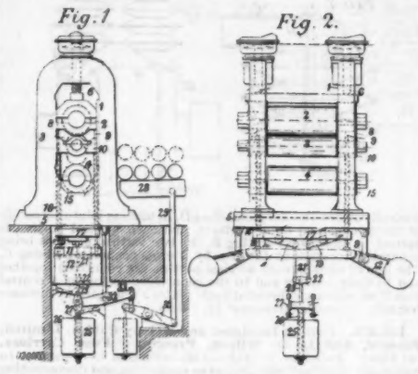
120,702. William Beardmore and Co., Limited, Parkhead, Glasgow, and T. Broadbent, Parkhead, Glasgow. Boring and Facing Tools. (3 *Figs.*) June 8, 1918.—A combined tool made according to the invention comprises essentially a sleeve bearing at its forward end the facing tool or edge which may be inset, but which is preferably formed integrally. Within the sleeve is a boring bar carrying at its forward end, which extends beyond the sleeve, a boring tool adjusted and secured therein in any convenient manner. The rear end of the sleeve is internally screwed to receive a plug against which the rear end of the boring bar is located—the position of the boring tool relatively to the facing tool being thus adjustable by screwing the plug inwards or outwards in the sleeve. A screw bolt or stud is passed through the plug into a screwed aperture in the rear end of the boring bar, which by this means may be drawn firmly against the plug and so be secured in its adjusted position. Any convenient means are provided to prevent the rotation of the



bar within the sleeve. The sleeve A has formed integrally with its forward part a facing tool A1. This is of helical form so that it may be resharpened by simple radial grinding. Within the sleeve is a boring bar B carrying a tool B1 contiguous to the facing tool. The rear end of the bar B butts against the inner face of a plug C screwed into the rear end of the sleeve A. A screw bolt C1 passed through the plug and screwed into the rear end of the boring bar serves to draw the bar firmly against the plug. The bar is held against rotation within the sleeve by a pin D forced into an aperture in it and engaging a slot D1 in the sleeve. The pin may be knocked out by a punch applied in an aperture D2 opposite the slot. The means for locating the boring tool is indicated, as applied to the bar, in dotted lines in Fig. 1, and consists of a sleeve E bored to fit the bar and counterbored to a diameter and depth to receive and so locate the tool B1. The sleeve may be lengthened and externally shaped to act, if desired, as a locating spigot in the fixture in which the boring bar is used. (*Accepted November* 27, 1918.)

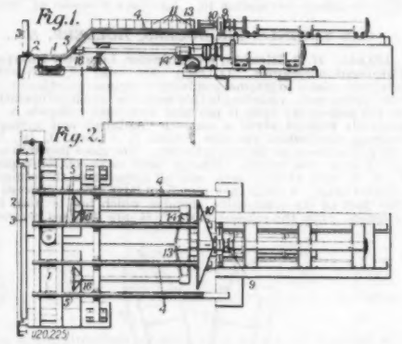
MINING, METALLURGY AND METAL WORKING.

120,703. A. Sahlin, London. Rolling Mills. (5 *Figs.*) June 10, 1918.—The invention relates to three-high plate mills. According to the invention, the floating middle roll 3 and the upper roll 2 are pressed upwards by counterweighted levers placed below the housing and the position of the floating middle roll is controlled by a counterweight which allows the roll to drop, when a table carrying the plate to be rolled is raised by suitable means. The housings 1 are supported by a sole plate 5; at the top of the housing adjustable screws 6 are set in contact with caps of the upper roll 2, which is mounted in bearings 8 resting on four rods 9; these rods pass through slots in bearings 10, in which is mounted the floating roll 3. The lower ends of the rods 9 are carried by a cradle 11, which is pressed upwards by weighted levers 12 suspended from the sole plate 5. The bottom roll 4 rests in bearings 15. The floating roll 3 is supported by four hollow rods 16 carried by a cradle 17, which is attached to the sole plate 5 by links and by pivoted levers 19. The free ends of the levers 19 are attached to an equalising crosshead 22. A rod 23 is pivoted to the crosshead 22 and has, at its lower end, a flange on which a counterweight 25 can rest. A hollow rod 26 carrying the weight 25 and surrounding the rod 23, is attached to a crosshead 27. When the hollow rod 26 and the weight 25 rest on the flange, the weight pulls the crosshead 22 down and lifts the cradle 17 and with it the rods 16, bearings 10 and balanced roll 3, which is forced against the top roll 2. When the roll is in this position, a space is formed between the rolls 3 and 4 through which space the plate being rolled passes on to a roller table 28, which is shown in its lowest position. When the plate has passed through the rolls, the table 28 is lifted into its highest position, carrying with it links 29, the lower ends of which are pinned to a counterweighted rocker 30. The rocker 30 is connected with the outer end of a balanced lever 32 pivoted to a rod 33 supported by the sole plate 5. The opposite end of the lever 32 engages with the crosshead 27, which is guided so that its centre moves



in a vertical line. As the crosshead rises, the hollow rod 26, with the counterweight 25, is lifted from the flange of the supporting rod 23. The floating roll 3 will then drop by its weight until it rests on the roll 4, at the same time depressing the rods 16, the cradle 17 and the attached ends of the levers 19, thus raising the links 21, the crosshead 22 and the supporting rod 23. The mill is now ready for the return of the plate through the space between the top roll 2 and the floating roll 3. (*Accepted November* 27, 1918.)

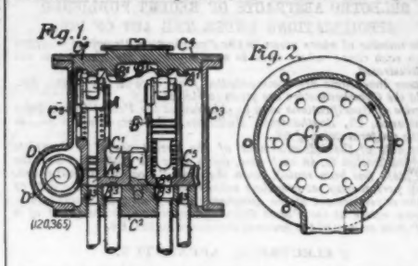
120,225. J. S. Atkinson, Westminster, London, Stein and Atkinson, Limited, Westminster, London, and B. F. Clark, Flixton. Ingot-Manipulating Apparatus. (2 *Figs.*) August 1, 1917.—This invention provides improvements in means or apparatus for use in the manipulation of ingots or other masses of metal in connection with appliances or apparatus for their treatment, such as furnaces, or for delivering ingots and other masses of metal at a required point. According to the present invention, means or apparatus for delivering billets at a required point, as, for example, within a continuous reheating furnace, comprises, in combination, a horizontal platform at the height at which the billets are to be delivered, a second horizontal platform arranged in line with the first platform and at a higher level, an inclined way joining the two horizontal platforms, and separately operable means for pushing billets along the said platforms, such, for example, as hydraulically-operated pushers. A platform formed by four rails 1, spaced apart, is arranged level



with the floor 2 of the furnace 3. A second platform is formed by four parallel rails 4 arranged at a higher level than the first. The two platforms are connected by an inclined way formed by four parallel rails 5. A hydraulic ram 9 is arranged on a level with the platform 4. The ram 9 carries a crosshead 10. Under the hydraulic ram 9 is arranged a second hydraulic ram 13 operatively connected to a crosshead 14. To each end of the crosshead 14 is secured a head 16. The heads 16 form the pushers for the ingots on the platform 1. In operation, a number of ingots 11 are arranged one behind the other on the platform 4. When it is desired to deliver, say, one of the ingots to the furnace 3, the ram 9 is put into operation, and the cross-head 10 coming into contact with the last ingot pushes all of the ingots forward until the first one slides down the inclined way 5 on the platform 1. The ram 9 is then stopped, and the ram 13 is put into operation. The cross-head 14 is moved forward until the heads 16 come into contact with the ingot on the platform 1, and push it therealong and into the furnace. (*Accepted November* 13, 1918.)

MOTOR ROAD VEHICLES.

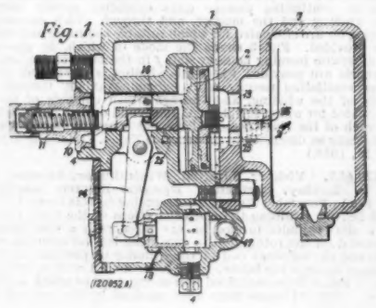
120,365. Albion Motor Car Company, Limited, Scotstoun, Glasgow, and T. B. Murray, Scotstoun, Glasgow. Mechanical-Feed Lubricators. (7 *Figs.*) August 3, 1918.—The invention relates to mechanical lubricators of the type in which a plunger pump is moved over a series of inlet and discharge ports with which its cylinder is thereby brought into successive communication while its piston is simultaneously operated by movement over a cam track. There are two pumps A, B, formed on a disc C mounted on a pivot-pin C1 on a base C2 which forms the bottom cover of a substantially cylindrical casing C3 forming an oil container, and which is closed at its upper end by a cover plate C4 on the under side of which are formed two concentric cam tracks A1, B1. Worm teeth C5 on the periphery of the disc C, are engaged by a worm D on a shaft D1 by which the apparatus is operated. In the base C2, are two concentric series of ports—inlet and discharge ports A2, A3, respectively communicating by way of a port A4, with the pump unit A, and inlet and discharge ports B2, B3, communicating by way of a port B4, with the pump unit B. The inlet ports A2, communicate by lateral passages with the interior of the casing C3, while the inlet ports B2 are connected with an extraneous source of lubricant. The outlet ports A3, B3, are connected to the points

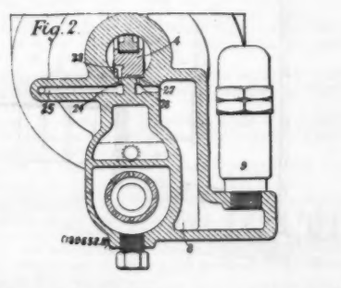


to be lubricated. Within the pump cylinder A there operates a plunger bearing at a roller engaging the cam track A1. A similar plunger within the pump cylinder B, and bears a roller engaging the cam track B1. (*Accepted November* 13, 1918.)

RAILWAYS AND TRAMWAYS.

120,652. J. W. Cloud, King's Cross, London. Fluid-Pressure Braking Apparatus. (3 *Figs.*) November 30, 1917.—This invention relates to fluid-pressure braking apparatus of the kind in which means are provided, in addition to the usual triple valve device, for obtaining a graduated release of the brakes. According to the present invention, fluid under pressure is supplied from the train pipe to a normally closed receptacle constituting the opposing resistance to the pressure or pressures controlling the exhaust of fluid under pressure from the brake cylinder, the degree of pressure in this receptacle, if in excess of a predetermined pressure, being automatically reduced when the brakes are applied. The valve mechanism comprises a casing 1, in which is a movable abutment 2 controlling a slide valve 4. The abutment 2 has an extension 10 adapted to accommodate one end of an adjustable spring 11. The movable abutment 2 is exposed on one side to the pressure of the fluid in the train pipe and the pressure of the spring 11, the other side being in free communication with the interior of the reservoir 7 through passages 13. In order to utilise the pressure of the fluid in the brake cylinder operating in conjunction with the train pipe pressure to oppose the pressure in the reservoir 7, a pivoted lever 14 is utilised, the upper arm of which engages a projection 16 on the slide valve in such a manner as to tend to move the valve in a longitudinal direction, when the pivoted lever 14 is displaced. In order that the brake cylinder pressure may be transmitted to act upon the movable abutment 2, the usual triple valve exhaust port is connected by means of a pipe (not shown) to a passage 17, leading to the interior of a movable abutment 18. The movable abutment 18 bears against the lower arm of the pivoted lever 14. The operation of the device is as follows: In the position shown,





fluid under pressure is supplied from the train pipe to the valve chamber 12, from whence it passes by the ports 23, 24, through the passage 25 and past the ball valve 26 to the reservoir 7; the movable abutment 2 is thus exposed on one side to the pressure in the train pipe together with the pressure of the spring 11, and on the other side to the pressure existing in the reservoir 7. The escape of fluid under pressure from the brake cylinder through the passage 17 is thus controlled by the movable abutment 2, but the slide valve 4 is adapted not only to control the flow of fluid from the train pipe to the reservoir 7, but also the flow of fluid from this reservoir when it is desired to reduce the pressure therein to a predetermined fixed pressure. In the application position of the parts, the slide valve 4 moves to a position in which the port 27 registers with port 28 leading to the chamber 8, which is in free communication with the interior of the blow-down valve 9 which permits the escape of fluid from the reservoir 7 until a predetermined pressure has been reached in the reservoir 7. By this means a definite degree of resistance to the brake cylinder pressure and the train pipe pressure is obtained, the pressure in the reservoir 7 being automatically reduced to a predetermined fixed pressure when the valve mechanism assumes a position such as will produce a partial or complete release of the brakes. (*Accepted November* 13, 1918.)